Appendix B
Modeling Process and Results

Appendix B

B. MODELING PROCESS AND RESULTS

TABLES

FIGURES

Appendix B

B.1 MODELING RESULTS

This section provides sustainable forest management modeling results for western Washington forested state trust lands managed by the Washington State Department of Natural Resources (DNR).

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Appendix B

DRAFT Reference Materials for July 6, 2004

Amended July 7, 2004

Sustainable Forest Management Modeling Results

For the
Board of Natural Resources

July 6, 2004
Washington Department of Natural Resources
1111 Washington St. SE
PO Box 47016
Olympia WA 98504-7016

Contents: Comparison of Alternatives

[1] County-specific data for the Forest Board Trust will be completed shortly

Changes in Forest Structure

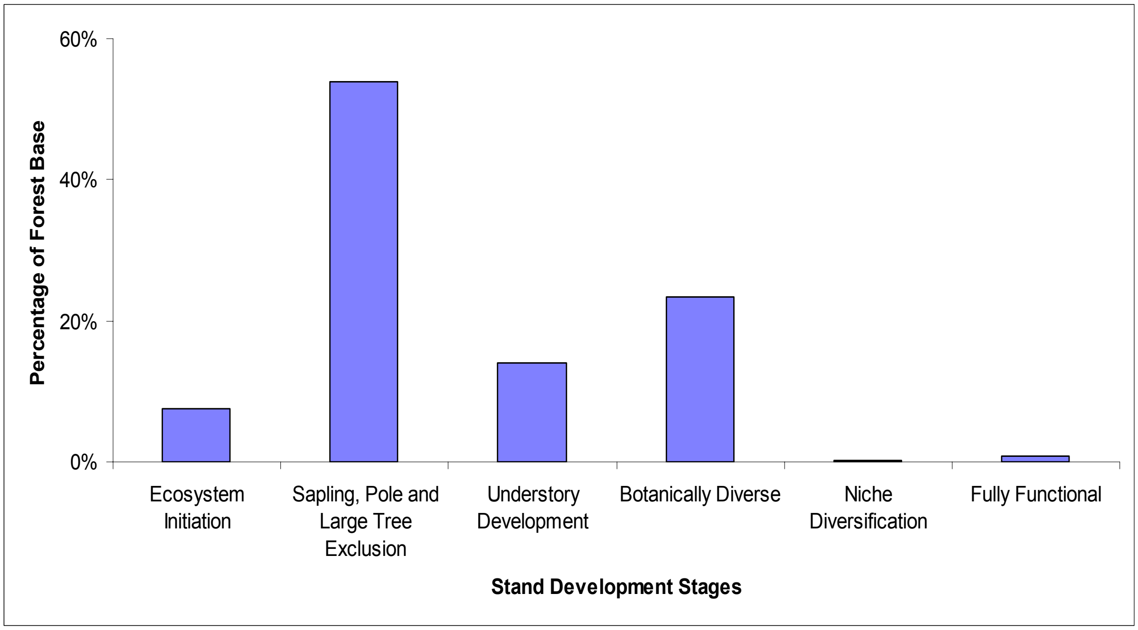


Figure B.1-1. Estimated Forest Structure in 2004

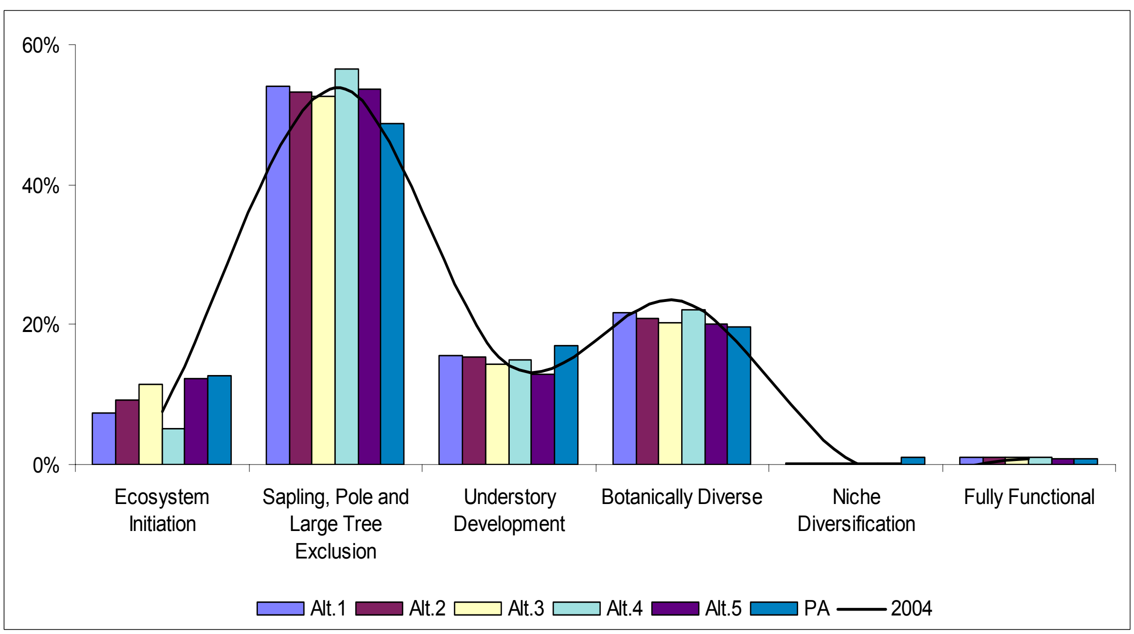


Figure B.1-2. Estimated Forest Structure in 2013

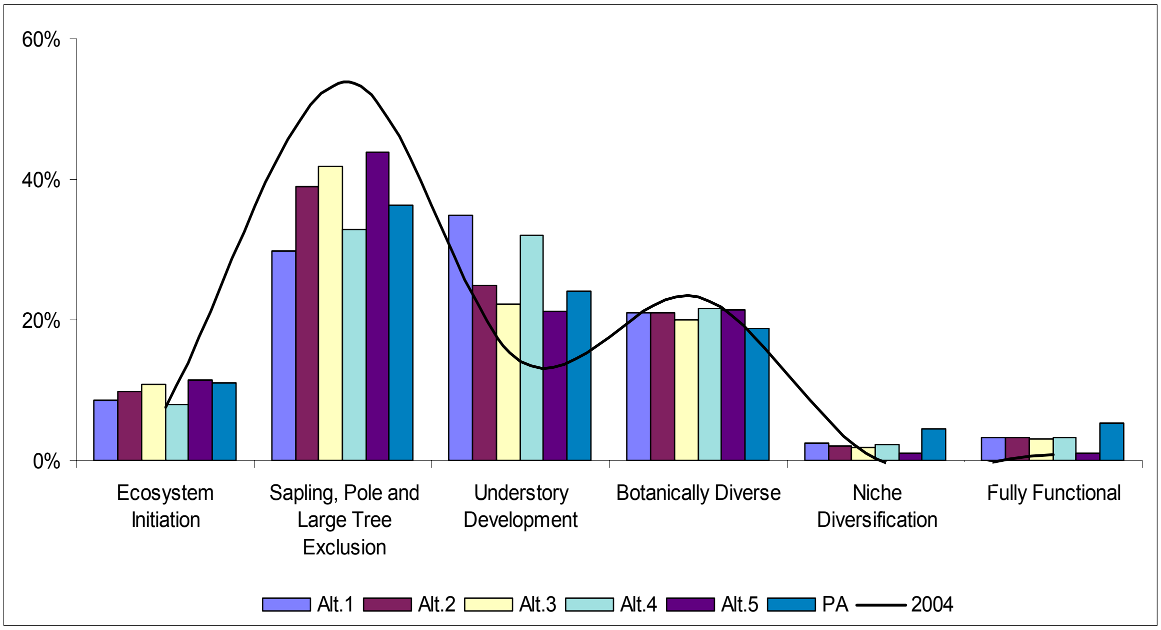


Figure B.1-3. Estimated Forest Structure in 2067

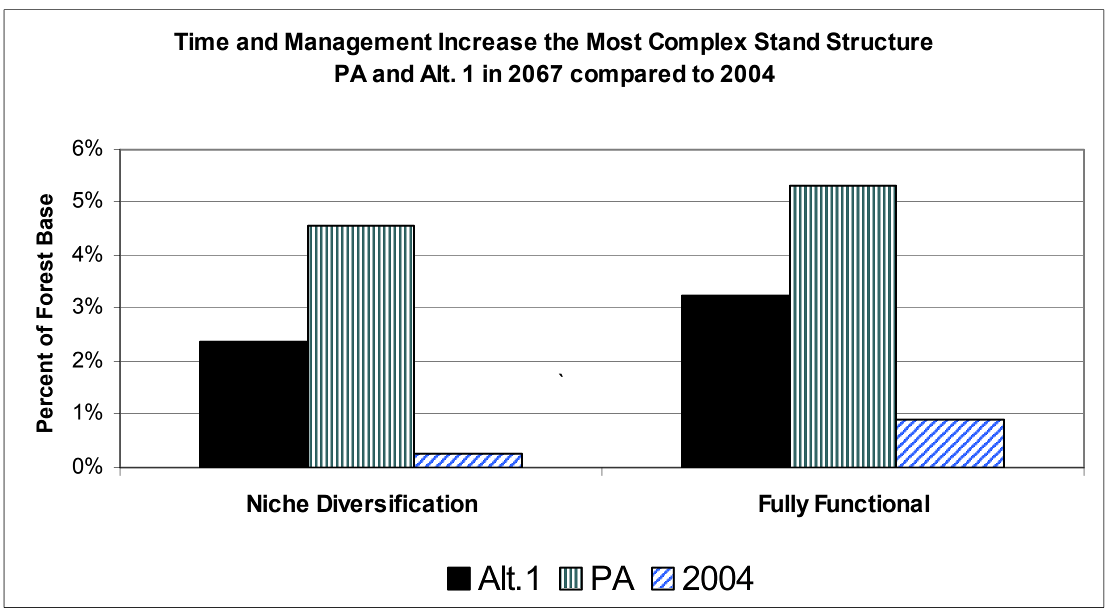


Figure B.1-4. Most Complex Stand Structure Comparison (2067 versus 2004)

Changes in Inventory

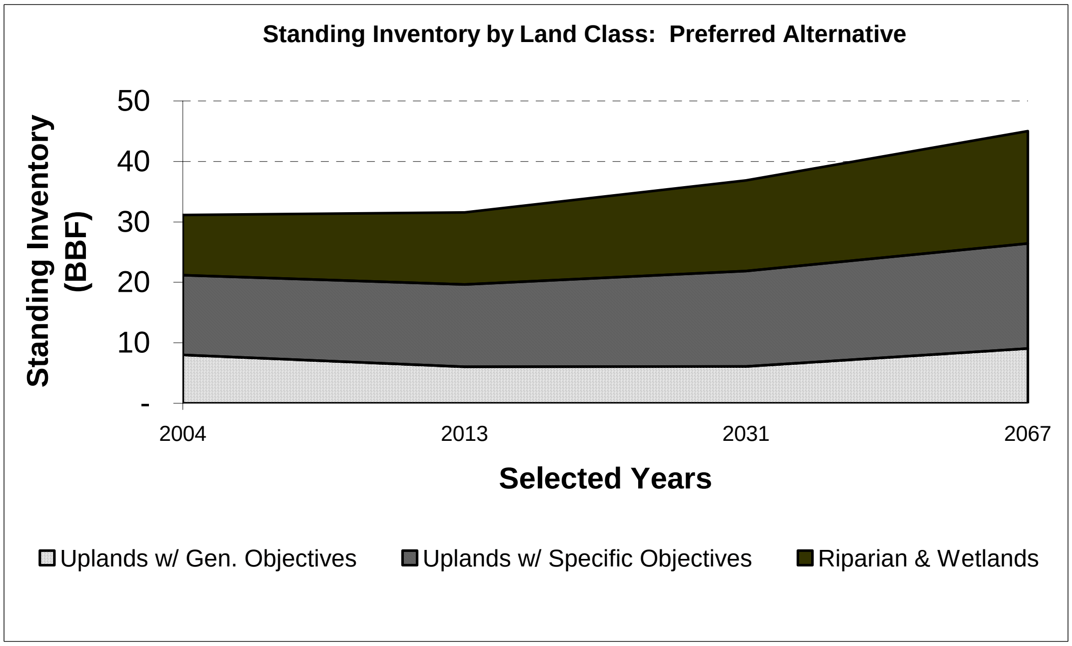


Figure B.1-5. Standing Inventory by Land Class for the Preferred Alternative

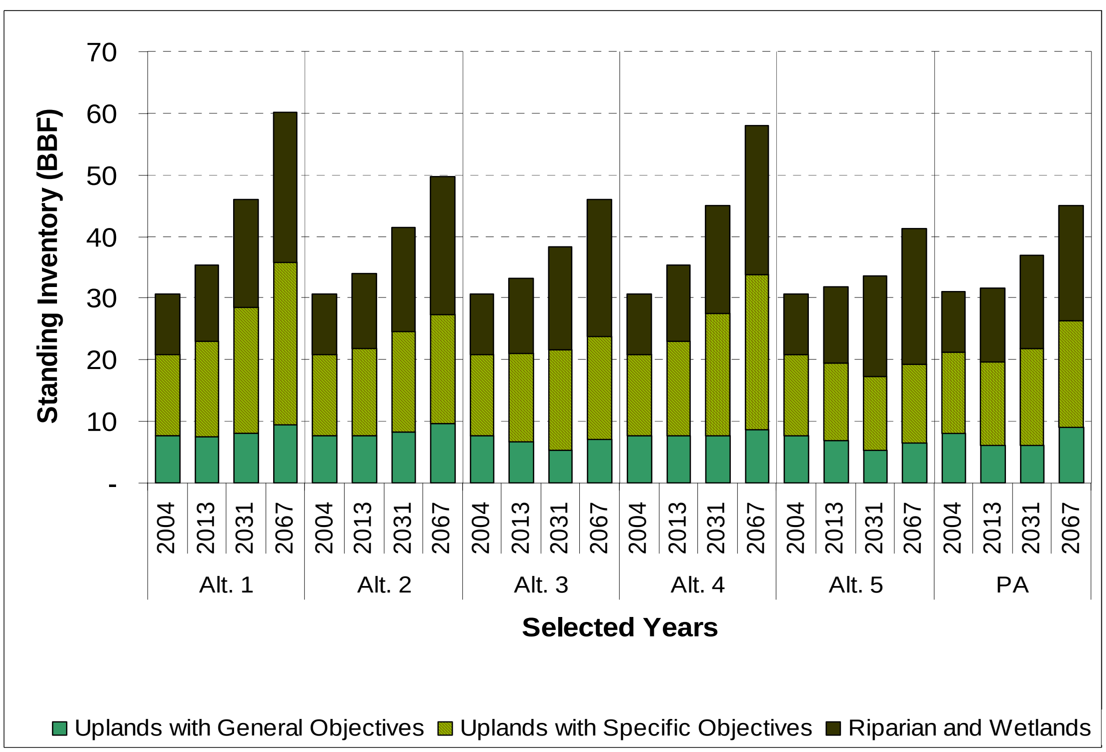


Figure B.1-6. Changes in Standing Volume by Alternative

Table B.1-1. On and Off-base Acres

				On-Base					
Year	Alternative	Off-base		Riparian and Wetland area		Uplands with Specific Objectives		Uplands with General Objectives	
		acres	%	acres	%	acres	%	acres	%
2004	Alt.1	763,000	55%		0%	322,500	23%	305,200	22%
	Alt.2	489,300	35%	214,800	15%	343,100	25%	343,500	25%
	Alt.3	514,400	37%	238,600	17%	328,100	24%	309,600	22%
	Alt.4	755,500	54%		0%	326,400	23%	308,800	22%
	Alt.5	513,400	37%	238,700	17%	329,600	24%	309,000	22%
	PA	515,500	37%	237,800	17%	327,800	24%	309,600	22%
2013	Alt.1	736,600	53%		0%	348,400	25%	305,700	22%
	Alt.2	281,100	20%	278,100	20%	477,200	34%	354,200	25%
	Alt.3	213,000	15%	346,200	25%	477,200	34%	354,200	25%
	Alt.4	573,400	41%		0%	463,500	33%	353,800	25%
	Alt.5	213,000	15%	346,200	25%	477,200	34%	354,200	25%
	PA	232,100	17%	329,000	24%	475,400	34%	354,200	25%

Harvest and Financial Data

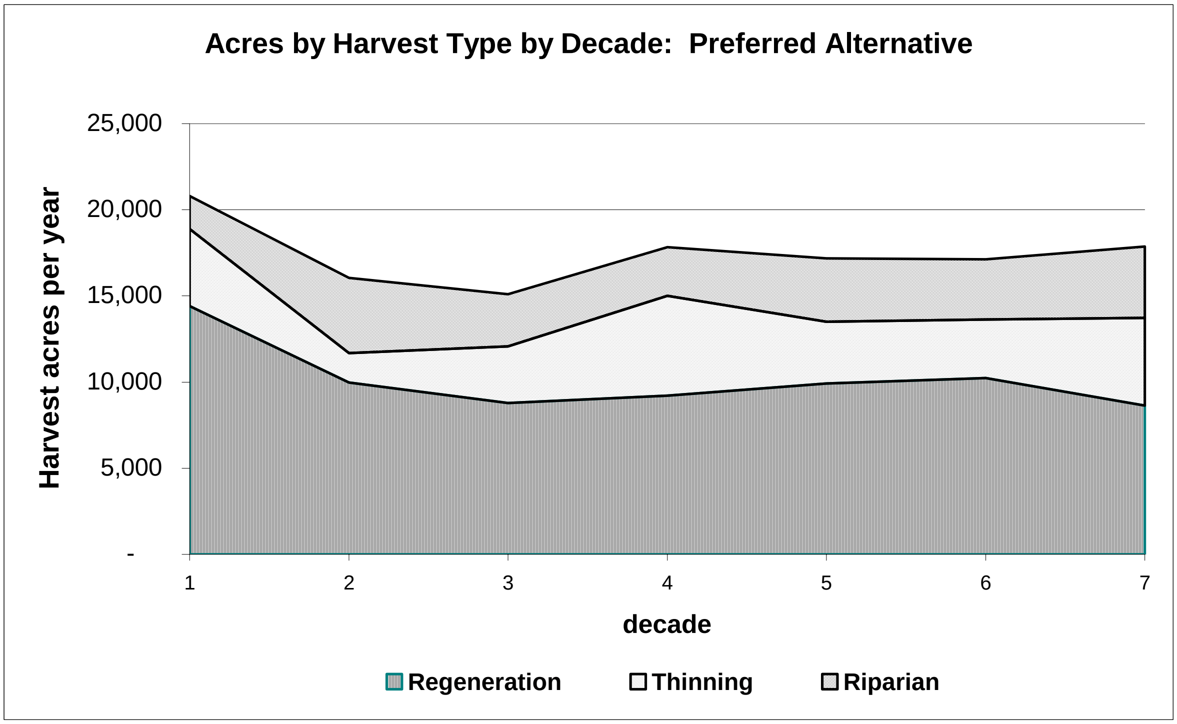


Figure B.1-7. Acres by Harvest Type for the Preferred Alternative

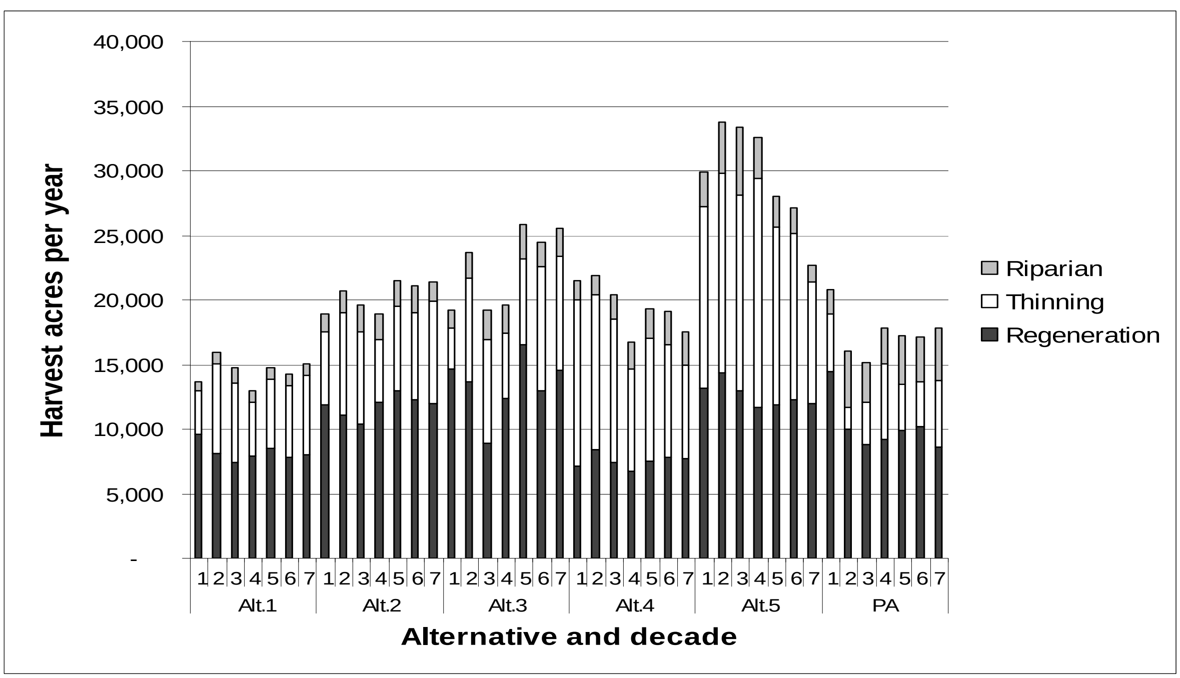


Figure B.1-8. Harvests by Type by Alternative for 7 Decades

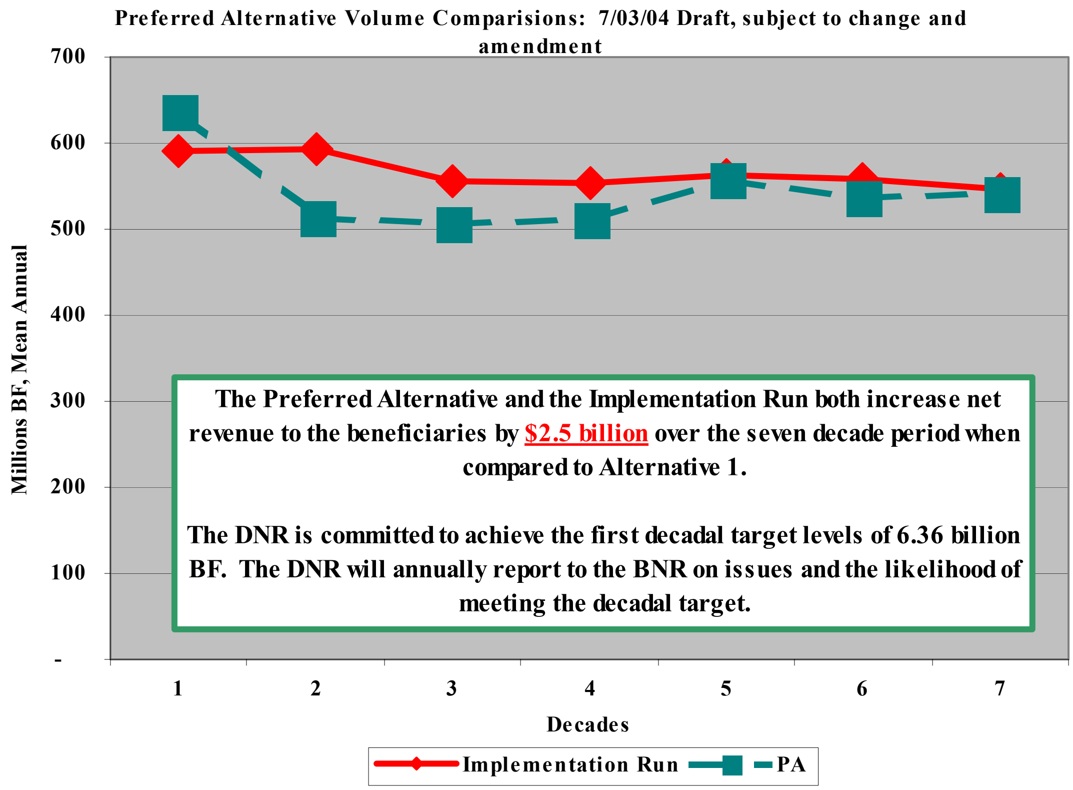
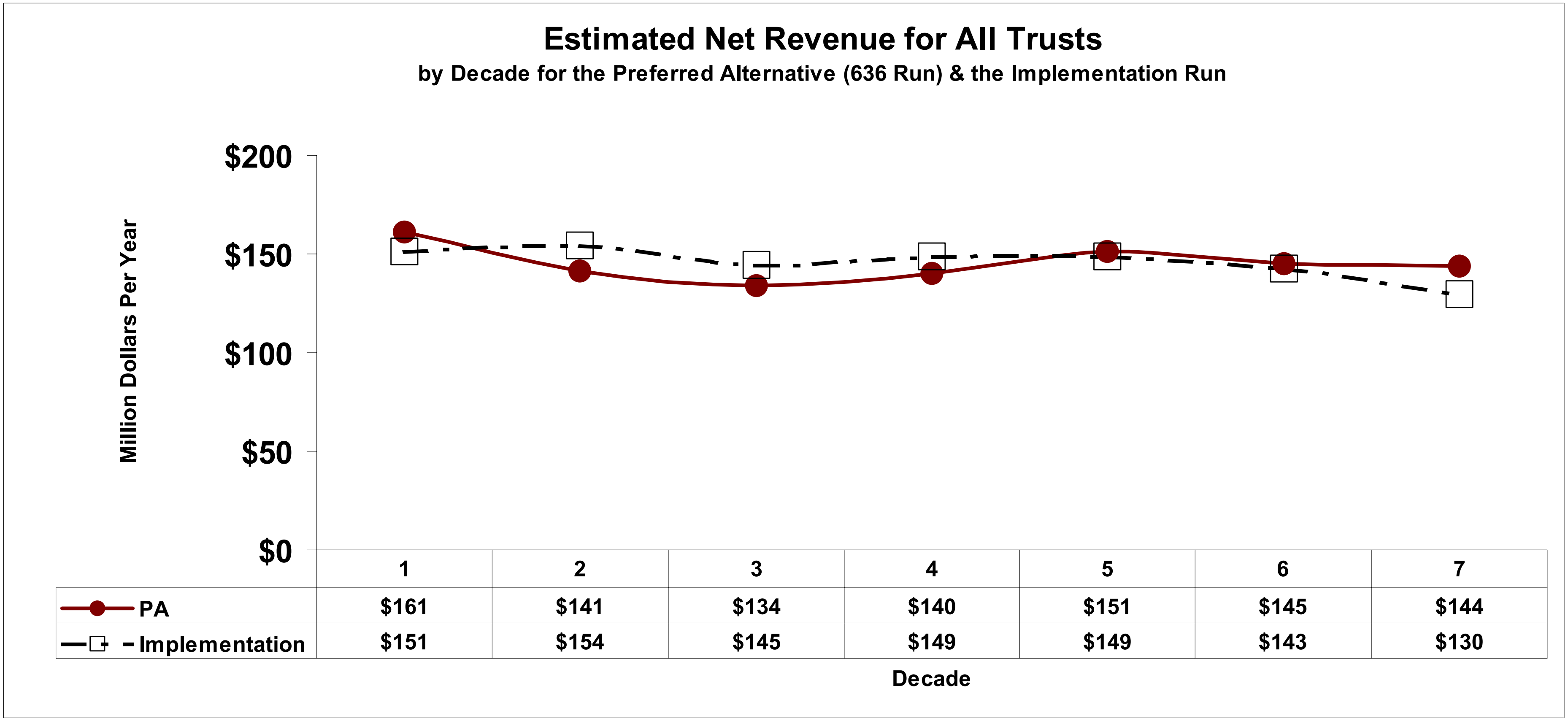


Figure B.1-9. Preferred Alternative Volume Comparisons

Table B.1-2. Net Returns to the Beneficiaries, a Comparison of the Preferred Alternative to Alternative 1

Net Revenue to Beneficiaries: Preferred Alternative and Alternative 1 (All dollars in millions)					
	Comparison of Annual Differences			Cumulative Decadal Difference	
Time Period	**Alt. 1**	**Preferred Alternative (PA)**	**Implementation Run**	**PA – Alt. 1**	**Implementation – Alt. 1**
1st Decade	$121.2	$161.0	$151.4	$397	$302
7 Decade Average	$109.7	$145.2	$145.7	$355	$360
Increase in net revenue to the beneficiaries over a 7 decade period				**$2,481**	**$2,520**



	1	2	3	4	5	6	7
PA	$161	$141	$134	$140	$151	$145	$144
Implementation	$151	$154	$145	$149	$149	$143	$130

Figure B.1-10. Preferred Alternative Net Revenue Comparisons

Table B.1-3. Gross and Net Revenue Comparison over 7 Decades: All Trusts for Selected Alternatives

All Trusts: All Values in Millions: PA = Preferred Alternative

Gross Revenue	Alternative			Decadal Differences	Decadal Differences
Decadecut	**Alt. 1**	**PA**	**Implementation**	**PA- Alt. 1**	**Implementation - Alt. 1**
1	$166	$219	$208	$529	$412
2	$158	$194	$209	$352	$504
3	$152	$183	$196	$310	$432
4	$154	$191	$201	$375	$472
5	$149	$205	$202	$559	$536
6	$147	$199	$197	$516	$495
7	$146	$196	$181	$501	$352
7 Dec. Avg.	$153	$198	$199		

Net Revenue	Alternative			Decadal Differences	*Decadal Differences*
Decadecut	**Alt. 1**	**PA**	**Implementation**	**PA- Alt. 1**	**Implementation - Alt. 1**
1	$121	$161	$151	$397	$302
2	$114	$141	$154	$270	$398
3	$109	$134	$145	$245	$353
4	$110	$140	$149	$297	$383
5	$106	$151	$149	$451	$431
6	$104	$145	$143	$410	$383
7	$103	$144	$130	$410	$271
7 Dec. Avg.	$110	$145	$146		

7 Decade Cumulative Increase in Net Revenue to Beneficiaries

PA- Alt. 1	Implementation - Alt. 1
$2,481	**$2,521**

Table B.1-4. Net Revenue to Beneficiaries: A Summary Comparison for All Trusts

All Values in Millions of Net Dollars to the Beneficiaries

Trust	**Net Revenue**	**Annual Values by Alternative**			**Decadal Differences**	
	Decadecut	**Alt. 1**	**PA**	**Implementation**	**PA- Alt. 1**	**Imple. - Alt. 1**
Total for	1	$121.2	$161.0	$151.4	$397.3	$301.7
	2	$114.3	$141.3	$154.1	$270.0	$397.9
	3	$109.2	$133.8	$144.6	$245.3	$353.3
	4	$110.5	$140.2	$148.8	$297.0	$382.8
	5	$106.0	$151.0	$149.1	$450.8	$431.1
	6	$104.3	$145.3	$142.6	$410.4	$383.1
	7	$102.7	$143.7	$129.7	$410.3	$270.7
All Trusts	7 Decade Avg.	$109.7	$145.2	$145.7	$354.4	$360.1

7 Decade Cumulative Increase in Net Revenue to Beneficiaries

PA- Alt. 1	***Imple. - Alt. 1***
$2,481.1	***$2,520.6***

The Preferred Alternative substantially increases net revenue to the beneficiaries.
Compared to Alternative 1, the Preferred Alternative will increase net revenue by about $2.5 billion over the seven decade period.
This number reflects all projected costs assumed in the model. All alternatives have costs greater than 25%.

Table B.1-5. Net Revenue to Beneficiaries: A Summary Comparison for Individual Trusts

Trust *All Values in Millions of Net Dollars to the Beneficiaries*

Trust	Net Revenue	Annual Values by Alternative			Decadal Differences	
	Decadecut	Alt. 1	PA	Implementation	PA- Alt. 1	Imple. - Alt. 1
Agricultural School	1	$2.7	$3.8	$3.7	$11.0	$9.4
	2	$2.4	$4.2	$3.9	$17.9	$15.0
	3	$1.8	$3.1	$3.8	$13.1	$19.8
	4	$2.0	$3.5	$3.3	$14.7	$12.6
	5	$1.7	$2.6	$2.7	$9.6	$10.4
	6	$2.0	$3.6	$3.5	$15.6	$15.2
	7	$1.6	$2.7	$2.7	$10.8	$11.0
	7 Decade Avg.	$2.0	$3.4	$3.4	$13.3	$13.4

7 Decade Cumulative Increase in Net Revenue to Beneficiaries

PA- Alt. 1	Imple. - Alt. 1
$92.8	$93.5

Trust *All Values in Millions of Net Dollars to the Beneficiaries*

Trust	Net Revenue	Annual Values by Alternative			Decadal Differences	
	Decadecut	ALT1	PA	Implementation	PA- Alt. 1	Imple. - Alt. 1
Capitol Grant	1	$8.7	$12.3	$11.9	$36.3	$32.3
	2	$6.7	$8.7	$9.0	$19.8	$23.4
	3	$5.5	$7.6	$7.9	$21.1	$24.1
	4	$5.4	$7.8	$8.0	$23.8	$25.1
	5	$5.0	$7.7	$6.9	$26.3	$19.1
	6	$4.7	$10.1	$10.8	$54.1	$61.2
	7	$4.9	$8.8	$7.7	$39.0	$27.4
	7 Decade Avg.	$5.9	$9.0	$8.9	$31.5	$30.4

7 Decade Cumulative Increase in Net Revenue to Beneficiaries

PA- Alt. 1	Imple. - Alt. 1

Table B.1-5. Net Revenue to Beneficiaries: A Summary Comparison for Individual Trusts (continued)

All Values in Millions of Net Dollars to the Beneficiaries

Trust	Net Revenue	Annual Values by Alternative			Decadal Differences	
	Decadecut	Alt. 1	PA	Implementation	PA- Alt. 1	Imple. - Alt. 1
CEP & RI	1	$5.0	$5.9	$5.8	$9.0	$7.6
	2	$4.0	$4.7	$4.9	$7.4	$9.5
	3	$3.4	$3.9	$4.1	$5.2	$7.5
	4	$3.9	$4.0	$4.1	$0.7	$1.9
	5	$3.2	$4.2	$3.8	$10.3	$6.3
	6	$3.4	$5.2	$5.4	$18.0	$20.0
	7	$3.0	$4.5	$4.5	$15.5	$15.9
	7 Decade Avg.	$3.7	$4.6	$4.7	$9.4	$9.8

7 Decade Cumulative Increase in Net Revenue to Beneficiaries

PA- Alt. 1	Imple. - Alt. 1
$66.0	$68.7

Table B.1-5. Net Revenue to Beneficiaries: A Summary Comparison for Individual Trusts (continued)

Trust — *All Values in Millions of Net Dollars to the Beneficiaries*

Trust	Net Revenue	Annual Values by Alternative			Decadal Differences	
	Decadecut	ALT1	PA	Implementation	PA- Alt. 1	Imple. - Alt. 1
Comn Schl & Indem	1	$50.2	$65.2	$63.0	$150.1	$127.8
	2	$48.8	$63.9	$67.7	$150.3	$189.0
	3	$48.8	$62.4	$63.8	$136.6	$150.3
	4	$49.6	$66.0	$67.9	$164.0	$183.3
	5	$49.4	$74.2	$73.1	$247.9	$237.5
	6	$46.8	$63.5	$62.3	$167.0	$155.2
	7	$48.0	$64.9	$59.1	$168.8	$110.8
	7 Decade Avg.	$48.8	$65.7	$65.3	$169.2	$164.9

7 Decade Cumulative Increase in Net Revenue to Beneficiaries

PA- Alt. 1	Imple. - Alt. 1
$1,184.7	$1,154.0

Trust — *All Values in Millions of Net Dollars to the Beneficiaries*

Trust	Net Revenue	Annual Values by Alternative			Decadal Differences	
	Decadecut	ALT1	PA	Implementation	PA- Alt. 1	Imple. - Alt. 1
Community College	1	$0.3	$0.2	$0.1	-$1.1	-$1.7
	2	$0.6	$0.8	$0.7	$1.7	$1.6
	3	$0.1	$0.5	$0.7	$4.4	$5.5
	4	$0.6	$0.7	$0.7	$0.6	$0.8
	5	$0.3	$0.2	$0.1	-$1.1	-$1.4
	6	$0.2	$0.2	$0.2	$0.4	$0.3
	7	$0.8	$0.7	$0.7	-$0.8	-$1.1
	7 Decade Avg.	$0.4	$0.5	$0.5	$0.6	$0.6

7 Decade Cumulative Increase in Net Revenue to Beneficiaries

PA- Alt. 1	Imple. - Alt. 1
$4.1	$4.0

Table B.1-5. Net Revenue to Beneficiaries: A Summary Comparison for Individual Trusts (continued)

Trust ***All Values in Millions of Net Dollars to the Beneficiaries***

Trust	Net Revenue	Annual Values by Alternative			Decadal Differences	
	Decadecut	ALT1	PA	Implementation	PA- Alt. 1	Imple. - Alt. 1
Escheat	1	$0.4	$0.3	$0.3	-$0.8	-$0.9
	2	$0.2	$0.3	$0.3	$1.4	$1.5
	3	$0.3	$0.3	$0.3	$0.5	$0.4
	4	$0.1	$0.5	$0.5	$3.5	$3.7
	5	$0.3	$0.5	$0.5	$1.2	$1.2
	6	$0.2	$0.2	$0.3	$0.7	$1.6
	7	$0.3	$0.2	$0.1	-$1.8	-$2.5
	7 Decade Avg.	$0.3	$0.3	$0.3	$0.7	$0.7

7 Decade Cumulative Increase in Net Revenue to Beneficiaries

PA- Alt. 1	Imple. - Alt. 1
$4.6	$5.0

Table B.1-5. Net Revenue to Beneficiaries: A Summary Comparison for Individual Trusts (continued)

Trust ***All Values in Millions of Net Dollars to the Beneficiaries***

Trust	Net Revenue	Annual Values by Alternative			Decadal Differences	
	Decadecut	ALT1	PA	Implementation	PA- Alt. 1	Imple. - Alt. 1
Normal School	1	$1.8	$2.3	$2.2	$5.0	$4.0
	2	$1.3	$2.2	$2.6	$8.7	$12.5
	3	$2.1	$2.9	$2.9	$8.8	$8.3
	4	$1.9	$2.5	$2.6	$5.6	$6.5
	5	$1.6	$3.6	$3.7	$19.3	$20.8
	6	$1.8	$3.1	$2.9	$12.9	$10.8
	7	$1.5	$4.3	$2.2	$28.3	$7.5
	7 Decade Avg.	$1.7	$3.0	$2.7	$12.6	$10.1

7 Decade Cumulative Increase in Net Revenue to Beneficiaries

PA- Alt. 1	Imple. - Alt. 1
$88.5	$70.5

Trust ***All Values in Millions of Net Dollars to the Beneficiaries***

Trust	Net Revenue	Annual Values by Alternative			Decadal Differences	
	Decadecut	ALT1	PA	Implementation	PA- Alt. 1	Imple. - Alt. 1
Scientific School	1	$6.3	$7.6	$7.5	$12.8	$11.8
	2	$6.7	$8.7	$9.2	$20.1	$25.0
	3	$5.0	$6.0	$6.1	$9.9	$10.3
	4	$5.1	$5.7	$5.2	$6.7	$1.0
	5	$3.9	$8.2	$7.8	$42.9	$39.0
	6	$4.0	$6.6	$6.6	$25.7	$25.9
	7	$3.4	$9.6	$8.0	$61.5	$45.5
	7 Decade Avg.	$4.9	$7.5	$7.2	$25.7	$22.7

7 Decade Cumulative Increase in Net Revenue to Beneficiaries

PA- Alt. 1	Imple. - Alt. 1
$179.6	$158.6

Table B.1-5. Net Revenue to Beneficiaries: A Summary Comparison for Individual Trusts (continued)

Trust — ***All Values in Millions of Net Dollars to the Beneficiaries***

Trust	Net Revenue	Annual Values by Alternative			Decadal Differences	
	Decadecut	ALT1	PA	Implementation	PA- Alt. 1	Imple. - Alt. 1
St Forest Bd Purch	1	$5.7	$6.4	$6.4	$7.1	$6.8
	2	$4.6	$6.9	$6.1	$23.2	$15.1
	3	$4.9	$4.1	$4.5	-$8.2	-$3.6
	4	$4.8	$4.9	$4.3	$0.8	-$5.2
	5	$3.6	$4.9	$4.6	$13.6	$10.7
	6	$4.7	$5.7	$5.7	$9.4	$9.6
	7	$5.3	$4.4	$4.0	-$9.6	-$12.9
	7 Decade Avg.	$4.8	$5.3	$5.1	$5.2	$2.9

7 Decade Cumulative Increase in Net Revenue to Beneficiaries

PA- Alt. 1	Imple. - Alt. 1
$36.2	$20.5

Trust — ***All Values in Millions of Net Dollars to the Beneficiaries***

Trust	Net Revenue	Annual Values by Alternative			Decadal Differences	
	Decadecut	ALT1	PA	Implementation	PA- Alt. 1	Imple. - Alt. 1
St Forest Bd Transf	1	$39.3	$54.3	$48.7	$149.7	$93.4
	2	$37.0	$38.7	$46.7	$17.0	$96.4
	3	$34.4	$38.4	$46.0	$39.1	$115.1
	4	$35.3	$41.3	$48.9	$60.3	$135.7
	5	$34.0	$43.1	$43.6	$91.7	$96.7
	6	$33.6	$43.2	$40.9	$95.7	$73.1
	7	$31.3	$41.1	$37.5	$97.8	$61.3
	7 Decade Avg.	$35.0	$42.9	$44.6	$78.8	$96.0

7 Decade Cumulative Increase in Net Revenue to Beneficiaries

PA- Alt. 1	Imple. - Alt. 1
$551.4	$671.7

Table B.1-5. Net Revenue to Beneficiaries: A Summary Comparison for Individual Trusts (continued)

Trust — ***All Values in Millions of Net Dollars to the Beneficiaries***

University - Original

Net Revenue	Annual Values by Alternative			Decadal Differences	
Decadecut	ALT1	PA	Implementation	PA- Alt. 1	Imple. - Alt. 1
1	$0.3	$0.2	$0.2	-$0.7	-$1.2
2	$0.2	$0.2	$0.2	$0.6	$0.6
3	$0.2	$0.4	$0.4	$2.1	$1.9
4	$0.2	$0.2	$0.3	-$0.1	$0.1
5	$0.2	$0.4	$0.5	$2.1	$3.0
6	$0.3	$0.3	$0.3	-$0.2	-$0.5
7	$0.3	$0.2	$0.2	-$1.4	-$1.4
7 Decade Avg.	$0.2	$0.3	$0.3	$0.3	$0.4

7 Decade Cumulative Increase in Net Revenue to Beneficiaries

PA- Alt. 1	Imple. - Alt. 1
$2.4	$2.6

Trust — ***All Values in Millions of Net Dollars to the Beneficiaries***

University – Transf

Net Revenue	Annual Values by Alternative			Decadal Differences	
Decadecut	ALT1	PA	Implementation	PA- Alt. 1	Imple. - Alt. 1
1	$0.4	$2.3	$1.7	$19.1	$12.4
2	$1.9	$2.1	$2.7	$1.9	$8.1
3	$2.8	$4.1	$4.1	$12.8	$13.4
4	$1.4	$3.1	$3.2	$16.4	$17.3
5	$2.8	$1.6	$1.6	-$13.0	-$12.3
6	$2.5	$3.6	$3.5	$11.1	$10.5
7	$2.1	$2.3	$3.0	$2.1	$9.3
7 Decade Avg.	$2.0	$2.7	$2.8	$7.2	$8.4

7 Decade Cumulative Increase in Net Revenue to Beneficiaries

PA- Alt. 1	Imple. - Alt. 1
$50.5	$58.8

Table B.1-6. Estimated Cumulative Present Net Value

NPV*	Alternative						
Decade	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Preferred Alternative	Implementation
1	$113	$143	$189	$104	$146	$151	$142
2	$220	$283	$375	$216	$307	$283	$286
3	$322	$427	$499	$322	$458	$408	$421
4	$425	$581	$673	$426	$595	$539	$560
5	$524	$726	$888	$540	$736	$680	$700
6	$621	$872	$1,045	$661	$886	$816	$833
7	$717	$1,012	$1,223	$782	$1,036	$950	$954

* Net Present Value in Million Dollars Per Year; Discount Rate = 5% Per Year

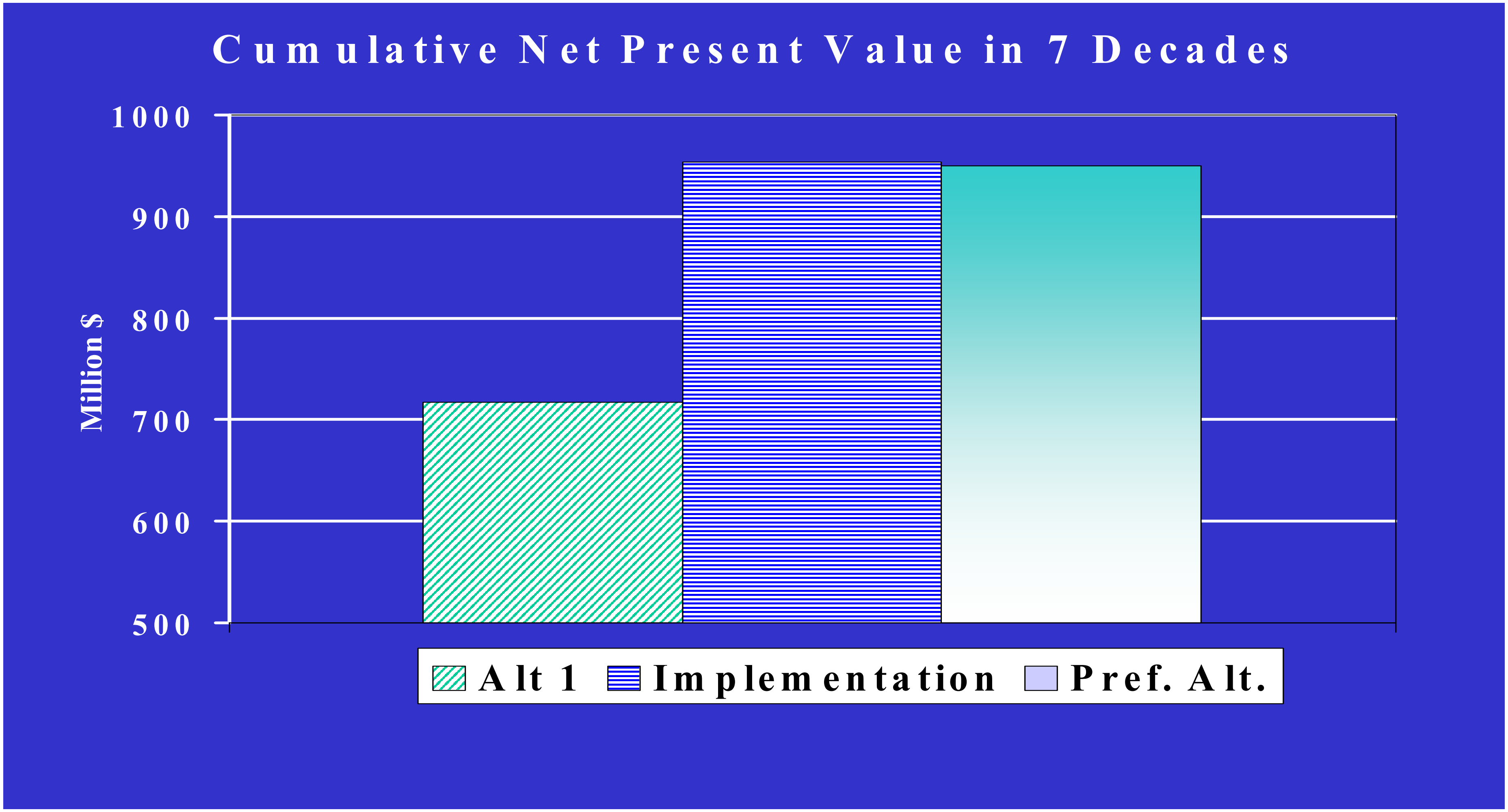


Figure B.1-11. Cumulative Net Present Value in 7 Decades for two Alternatives

B.2 MODELING INPUT AND PROCESS

B.2.1 Technical Note No. 1: Description of Growth and Yield Modeling Updates for the 2004 Sustainable Harvest Calculation

Attached is a technical paper describing growth and yield modeling improvements for the sustainable harvest calculation prepared by DNR.

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Technical Note No. 1

Description of growth and yield modeling updates for the 2004 sustainable harvest calculation

W. Jaross, B. Lu, A. Brodie, and D. Riemer

The growth and yield methods supporting the stand development stages and value-based Alternatives (DNR 2003) were identified as having potential flaws. The initial yield tables accelerated stand development and inflated volumes for the value-based calculations (Alternatives 5 and the Preferred Alternative). The volume-based calculations (Alternative 1 through 4) were not identified as a concern as a result of these issues. Specifically, three comments were received supporting the growth and yield updates (DNR, March 8, 2004).

- "The projections of increased structurally complex forest using either passive management or standard commercial thinning are overestimates".
- "The economic analysis presented to date appears to be solely based on timber prices times log volume and is so inferior that one can make no judgments on what treatments are economic"
- "Volume estimates, too high?" (South Puget Sound Region Office, January 9, 2004)

To improve the stand development stages and value-based calculations (Alternatives 5 and the Preferred Alternative), the 2004 Sustainable Harvest calculation needed to reflect more site-specific values, densities, and stocking levels. Three corrections were considered.

- More inventory variables were passed to the OPTIONS V™ model (Table B.2.1-1).
- Yields tables were reviewed and revised to match the density and stocking levels observed in the Department's forest inventory (Reimer, February 26th, 2004)
- Stumpage and volume were estimated for forest inventory stands (Equations 1 & 2).

Table B.2.1-1. Estimated Forest Inventory Stand Variables Passed to the OPTIONS V™ Model (Lu, April 26, 2003)

Stand Level Variable	Initial Runs	Updated Runs
Inventory Classification (Species, Age, Site Class)	Species class defined by trees per acre.	Species class defined by basal area per acre.
Stocking	Not imported	Imported All trees >2" diameter at breast height (dbh)
Basal Area	Not imported	Imported All trees >2" dbh
Diameter	Not Imported	Imported All trees >2" dbh
Volume (value)	Imported cubic feet per acre (Alts 1-4)	Imported $/acre (Alts 5 & PA)
Height	Not imported	Not imported

Equation 1. Converting inventory cubic feet to stumpage value.

$$Value_{\text{ model (\$/acre)}} = Cubic\ Feet_{\text{ merch inventory (cft/acre)}} * \frac{Value_{\ yield\ (species,\ site,\ age)}}{Cubic\ Feet_{\ yield\ \ (species,\ site,\ age)}}$$

Equation 1 estimated a stumpage value using a conversion ratio (Bowering and Lu, circa 2002) specific to species composition (Lu, January 27th, 2003), origin (planted or naturally regenerated), site class (WAC-222), and 10-year age class of the revised yield tables built using SPS (Arney 2002). Value output from the OPTIONS V™ model was converted to Scribner volume (board feet) and gross revenue specific to species composition, height and quadratic mean diameter (qmd). Equation 2 applied ratios derived from the yield analysis and a correction for timber utilization.

Equation 2. Converting OPTIONS V™ model value to Scribner board feet.

$$Board\ Feet_{\text{ merch (bf/acre)}} = Value_{\text{ model (\$/acre)}} * \frac{Board\ Feet_{\ yield\,(species,\ site,\ age)}}{Value_{\ yield\ (species,\ site,\ age)}} * \left(\frac{qmd_{\text{ model}}}{height_{\text{ model}}}\right)^{0.125}$$

The timber utilization exponent of 0.125 in Equation 2 was arrived at through trial and error. This exponent adjusted the Scribner board foot estimates to more closely reflect the Department's advertised sales volumes. Utilization adjustments were the same for stands with the similar height and diameter ratios. It was assumed that leaving an average of eight trees per acre resulted in 6% yield reductions. Further reductions are assumed to result from hard-to-reach locations within harvest units. In total, the model values, corrected for timber utilization, were adjusted by 10.8% (6% for leaving trees and 4.8% operability). The gross revenues and DNR timber sale costs were calculated from the Scribner board foot estimates using the cost estimates and stumpage prices presented in Tables B.2.1-2 and B.2.1-3.

Table B.2.1-2. Summary of Timber Sale Cost Assumptions ($ / thousand board feet)

REGION	Regular Sale	Thinning Sale	Partial Cut Sale
Northwest	18	36	24
South Puget Sound	18	36	24
Southwest	15	30	20
Central	18	36	24
Olympic	21	42	28
Olympic Experimental State Forest	21	42	28

Table B.2.1-3. Summary of Stumpage Rate Assumptions Applied to Scribner Volume Estimates (Bowering and Lu, circa 2002) ($ / thousand board feet)

Forest Type	Regular Sale	Thinning Sale	Partial Cut Sale
Douglas fir	376	183	287
Douglas fir – non-Commercial	200	73	117
Douglas fir – hardwood	321	111	160
Douglas fir – red cedar	478	166	278
Douglas fir – western hemlock	332	132	233
Non-commercial	114	44	60
Non-commercial – conifer mix	170	62	99
Non-commercial – hardwood mix	175	68	92
Hardwood	296	108	173
Hardwood – Douglas fir	296	108	173
Hardwood – western hemlock	372	136	217
Red cedar	440	161	193
Red cedar – Douglas fir	448	164	197
Red cedar – hardwood	432	158	190
Red cedar – western hemlock	415	161	219
Silver fir	212	77	123
Western hemlock	250	102	139
Western hemlock – Douglas fir	286	106	174
Western hemlock – hardwood	175	68	92
Western hemlock – red cedar	415	161	219
Western hemlock – silver fir	212	82	88

Conclusions

The Department reviewed and revised the growth and yield methods for the 2004 Sustainable Harvest calculation of forested state trust lands in Western Washington managed by the state Department of Natural Resources.

The improvements “slowed” stand development and provided more realistic volumes from the value-based calculations (Alternatives 5 and the Preferred Alternative). This was accomplished by passing more inventory variables to the OPTIONS V™ model, matching the density and stocking levels observed in the Department’s forest inventory, and estimating stumpage for each forest inventory stand.

The revised growth and yield forecasts more closely matched the experience of forest stand structures and stumpage revenues. The review also demonstrated that the original volume-based yields were acceptable. Therefore, the volumes calculated for Alternatives 1 through 4 were not a concern. As a result, the Department updated the value-based calculations (Alternatives 5 and the Preferred Alternative) and redesigned the stand development stages for all the Alternatives.

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B.2.2 Technical Note No. 2: Modeling Forest Stand Development Stages for Strategic Modeling of Forested State Trust Lands in Western Washington

Attached is a technical paper describing the stand development stage model developed by DNR.

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Technical Note No. 2

Modeling forest stand development stages for strategic modeling of forested state trust lands in western Washington

A.W. Brodie, W. Jaross, B. Lu and D. Lindley

This paper describes the stand development stage model developed by the Washington State Department of Natural Resources (Department). A brief introduction describing the purpose of stand structure and the management objectives of the Department's Habitat Conservation Plan will be included. Also, the Department's initial and current classification schemes will be discussed and illustrated with examples. More detailed information on the programming code changes will be provided in the appendices.

Introduction

As part of the 2004 Sustainable Harvest calculation of forested state trust lands in Western Washington managed by the state Department of Natural Resources (Department), the Department developed a stand structural classification model called Stand Development Stages (SDS). For the calculation, the SDS model illustrates the effects of forest management on the developmental stages of forest structure over time.

The Department reviewed the SDS model during further analysis between the Sustainable Forest Management Draft Environmental Impact Statement (EIS) and Final EIS. The model was restructured so that new information could be considered in the Board of Natural Resources (Board) decision to adopt a suite of policy changes and a new Sustainable Harvest level.

The revisions to SDS modeling for the Final EIS "slow" the development of the forest structure over time, similar to Forest Vegetation Simulator (FVS) simulation runs under a no management scenario. The results of the revisions reflect the expectations of forestry expert reviews.

The purpose of a stand development stage model

During the latter half of the 1990s the Department developed and agreed to a Habitat Conservation Plan (HCP) with the US Federal Agencies responsible for threaten and endangered species and their habitat (USFW and NMFS) (WADNR, 1997). Under the HCP the Department has management strategies to meet various habitat objectives on state trust lands for northern spotted owls, marbled murrelets, salmonid and riparian obligate species, and unlisted species of concern, within the range of the northern spotted owl. The HCP objectives call for conservation of populations through provision of habitat conditions that are anticipated to contribute to demographic support, dispersal, and maintenance of geographic distribution of northern spotted owls across the landscape.

The Department's Habitat Conservation Plan uses a combination of landscape and stand-scale strategies for the management of forest conditions to meet specific and general habitat requirements. The stand-scale strategies are described as a set of forest conditions in terms of forest structure: for example, number and size of live and dead trees (snags) and dead wood debris of various sizes and conditions. An assumption is made that if the forest contains the identified structural conditions across the specific landscapes, the species' habitat requirements will be met. During the development of the Habitat Conservation Plan, a stand development stage model based on improved inventory was envisioned (WADNR 1997, pages HCP IV 180-181).

Arriving at a common understanding of forest structural development requires some means of describing the attributes that concern the purposes of forest management. Structural attributes embody the elements of change necessary to achieve management objectives related to biodiversity conservation and habitat management. Structure is a more readily measured surrogate for functions (e.g. productivity or as habitat for organisms) that are difficult to measure directly. Structure has direct value as a product (e.g. wood) or in providing a service (e.g. in sequestering carbon or influencing hydrologic responses (absorbing heavy rainfall, etc)(Franklin et al, 2002).

For commercial even-age silviculture, the features of stand development – primarily age and tree sizes – have proven useful to foresters. As the Department's objectives have evolved to include biodiversity and habitat conservation, those familiar metrics alone become ineffective depictions of the new management objectives. Objectives such as maintaining and sustaining biodiversity and productivity require forest managers to relate to the ecological principles of stand development. Structural classifications present a vocabulary that describes more than just the productive importance of stand development.

The Department's Stand Development Classification System

The Department's stand development stage model describes the forest in terms of stand structure and forest development and draws from recent works by Franklin et al. (2002), Johnson and O'Neil (2001) and Carey et al. (1996) and Habitat Conservation Plan (WADNR, 1997). The Department built upon the nomenclature and descriptions of stand development stages from Carey et al. (1996). Carey's stand development classification was selected because it focused on the relationship of ecological process and stand development. For the purposes of this modeling exercise, no explicit linkages are made to any specific wildlife habitat suitability models.

Authors in the forest ecology and forestry literature (Franklin et al. 2002; Carey et al. 1996; O'Hara, et al. 1996; Spies and Franklin, 1996, Oliver and Larson, 1990) also have developed classifications describing stand development. However, most of these classifications are conceptual in nature or are built from a specific set of stand data, and must be applied to similar datasets to support repeatable conclusions.

Several information sources were considered during the development of the stand development stage model. These consisted of:

- Diameter class and stand-level information from the Department's Forest Resource Inventory System (FRIS). FRIS 1 is sample-year data, while FRIS 2 is projected ("grown") and updated for management activities to current-year (November, 2002, 2003);
- Simulated FRIS 1 under a "no management" scenario using the USDA Forest Service Forest Vegetation System (FVS). This provided information of number of canopy layers per stand and the likely development of future canopy layers under no

management over a 100-year period. Default keyword parameters were used for "StrClass"[1] and related FVS variables (Crookston and Stage, 1999)

- Decay rates for snags and coarse woody debris from coarse woody debris dynamics simulator (Marcot et al., 2002).

There were two iterations of the SDS model. The results of the initial stand development stage model were published in the Draft EIS (WADNR, November 2003). A reviewer (Paula Swedeen, Department of Fish and Wildlife) thought the Draft EIS SDS projections overestimated the amount of change from a competitive exclusion stage to more structurally complex stage. Also, the Department own reviews of the Draft EIS Sustainable Harvest calculations indicated that revisions to the SDS model were necessary.

Figures 4.4-1 of the Draft EIS illustrated Alternatives 1 and 4 (the more passive management alternatives) simulated more structurally complex forested habitat types (botanically diverse, and greater) than the other management Alternatives, (WADNR, 2003). Even Alternative 6, which promoted specific strategies and activities (biodiversity thinning) aimed at creating more structurally complex forested habitat types, developed less. This result was neither intuitive nor expected.

Concurrently, the Department observed few changes in structural complexity from a100-year no-management simulation produced with the USDA Forest Service Forest Vegetation System (FVS). These FVS results were consistent with both the Department's and the reviewer's opinions that the Draft EIS SDS overestimated the rate of change. .

In addition, the Department updated the yield valuations for Alternatives 5 and the Preferred Alternative (Jaross et al., 2004). The yield revisions reflected stocking of all trees, not just the commercial cohort and therefore the initial stand development stage assumptions were no longer appropriate. The details of the initial and revised approaches are discussed herein.

Initial Approach to the Department's stand development stage model

The Department's initial stand development stage (SDS) model approach was developed around a set of growth and yield assumptions based primarily upon a commercial even-aged cohort (Jaross et al., 2004).

The main determinate for the initial stand development stage model was average stand diameter (quadratic mean diameter or QMD) development. Trees per acre (TPA), Curtis's relative density (Curtis, 1982), and management occurrences (thinning) were included. Stand age also played a role. For further details see Table B.2.2-1.

A relative density (RD) threshold condition of 44.6 (Oliver et al, 1995), was assumed to distinguish an open stand condition from a closed one, as well as distinguishing a single story stand from stands with multiple canopy layers. Management activities, such as thinning were assumed to affect canopy layers and closure. Figure B.2.2-1 illustrates the distribution in 2004 and expected changes in stand development changes as presented in the Draft EIS.

[1] Use of the keywords and post processes was made without any attempt at changing the default values.

Table B.2.2-1 presents the variables and logic for the initial stand development stage model. Notice that diameter and age are distinguishing the stages. Programming code is provided in the attachments.

Table B.2.2-1. Initial SDS Classification - Coded Variables

Forest Structure Class (FSC) adapted from Johnson and O'Neil (2001)	Stand Development Stage (SDS) adapted from Carey et al (1996)		Logic	Stand-level Variable and Associated Shreshold Value					
				QMD	RD	TPA	Management Activity: Thin Age	Management Activity: Frequency	Stand Age
Grass_Forb	EIS	Ecosystem Initiation		<1					
ShrubSap			or	>=1 & <5	<=44.6	<=328			
ShrubSap_closed	SES	Ecosystem Initiation		>=1 & <5	>44.6				
ShrubSap_closed			or	>=1 & <5		>328			
Pole_multi	URS	Understory reinitiation		>=5 & <10	<=44.6		>25	>=1	
Pole_multi			or	>=5 & <10	<=44.6			<0	>=40
Pole_multi_closed	PES	Pole exclusion		>=5 & <10	>44.6		>25	>=1	
Pole_multi_closed			or	>=5 & <10	>44.6			<0	>=40
Pole_single_closed			or	>=5 & <10	>44.6				
Pole_single	URS	Understory reinitiation		>=5 & <10	<=44.6				
Large_multi_closed			or	>=10 & <19	>44.6		>45	>=1	
Large_multi_closed			or	>=10 & <19	>44.6			<0	>=160
Large_multi_closed			or	>=10 & <=14	>44.6				
Large_single			or	>=10 & <19	<=44.6				
Large_single			or	>=10 & <19		<=150			
Large_single_closed	LTS	Large tree exclusion		>=10 & <19	>44.6	>150			
Large_multi	DUS	Developed understory		>=10 & <19	<=44.6		>45	>=1	
Large_multi			or	>=10 & <19	<=44.6			<0	>=160
Large_multi			or	>14 & <19	<=44.6				
Giant_multi	BDS	Botanically diverse		>=19 & <=23		<130		<2	
Giant_multi			or	>=19 & <=23			>55	>=2	
Giant_multi + HE_ND	NDS	Niche diversification		>=19 & <=23		>=130			
Giant_multi + HE_ND			or	>=19 & <=23				>=2	
Giant_multi + HE_FF	FFS	Fully functional (mgd)		>23		>=95			
Giant_multi + HE_FF			or	>23				>=1	
Giant_multi + HE_FF			or	>23			>85	>=2	
Giant_multi + HE_FF			or	>23		<95		<1	<250
Old Natural Forests	ONF	Old Natural Forests		>23		<95		<1	>=250

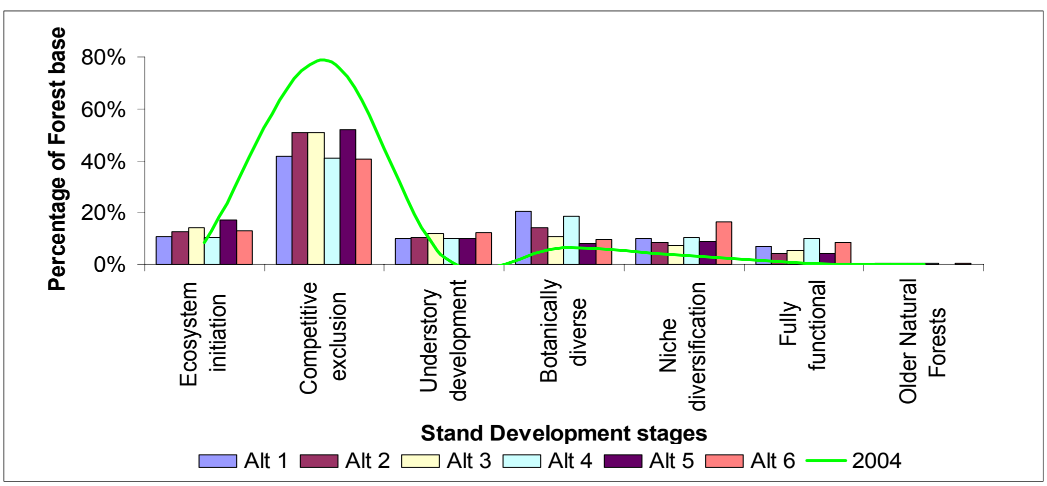

Figure B.2.2-1. Percent of Total Forest Base in DEIS SDS stages for the Alternatives 2067 (HCP planning horizon)

The Department's Revised Stand Development Stage model for the Final EIS

The SDS model was re-designed to address the shortcomings observed in the initial modeling logic, as well as to incorporate new information. The initial stand development stage model distinguished development stages mostly by diameter and age. The Department changed the principle determinates to reflect a process of multiple canopy development, closure, and decadence. The role of thinning was included in the revised classification logic.

The stand development stage in year 2004 was modeled using new information. As Figure B.2.2-2 illustrates, an FVS simulation provided an indication of canopy layers for each stand.

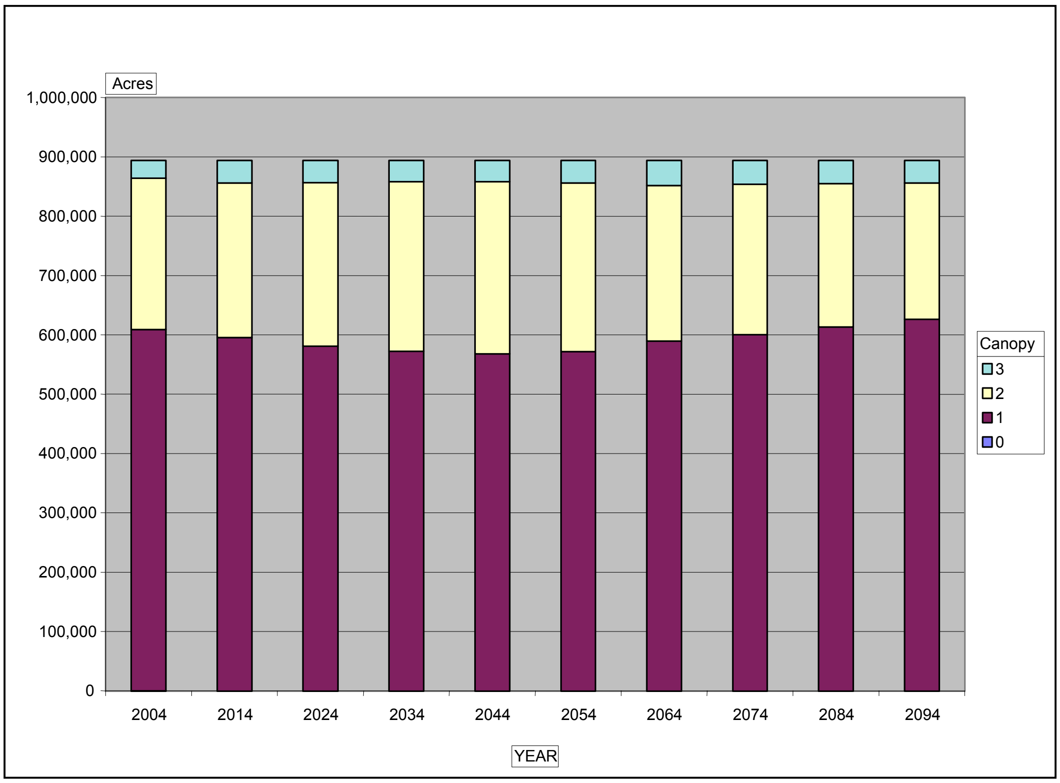

Figure B.2.2-2. A No Management Scenario Using FVS Illustrates Little Change in the Acre Distribution of Canopy Layers over a 100-year Simulation

Consistent with the findings illustrated in Figure B.2.2-2, the Department assumed that without management, the possibility of increased complexity for forest stands was conditional upon competition induced mortality. The Department assumed that stands passing maximum relative density would develop decadence and an understory through natural processes. This transition period was labeled *understory development stage* (UDS). After a period of time, a stand would develop into a botanically diverse or niche diverse state. Decadence played a role in distinguishing between the *botanically diverse stage* (i.e. multiple canopy layers and species) and a stage that has structural complexity and snags and course woody debris. These time periods were adjusted through trial and error, until the modeling results were consistent with the model validations and forestry expert reviews.

Thinning could either perpetuate or change a stand development stage. For example, a removal of less than 50 percent of the standing basal area in a thinning from below was expected to perpetuate the competitive exclusion state (or current stage).[2] It was assumed that increased removals, creating gaps, and recruiting snags and coarse woody debris from the dominant canopy, increased the likelihood that stands would transition from a competitive exclusion stage. However, thinning did not automatically introduce structural complexity. The Department assumed that some time was necessary for decadence and the planted and naturally regenerated understory to establish. These time periods were adjusted through trial and error, until the modeling results were consistent with the new information. Figure B.2.2-3 illustrates the Department's revised stand development stage model.

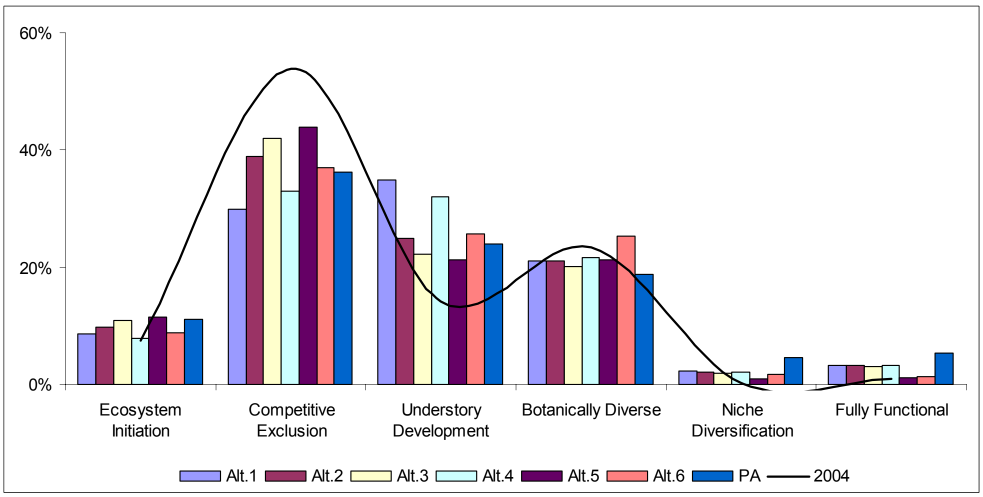

Figure B.2.2-3. Percent of Total Forest Base in FEIS SDS Stages for the Alternatives in Year 2067 (HCP planning horizon)

Table B.2.2-2 presents the variables and logic for the Department's revised stand development stage model. Programming code is provided in the attachments. Note that stand age is used differently in the revised approach. For the sake of simplifying the algorithms, yield table ages corresponding with maximum relative density signaled the passing of peak relative density, and the onset of understory development and the more structurally complex stages.

[2] The 50 percent breakpoint was imprecise and arbitrary, however, the basic concepts of how thinning intensities can affect the dominant tree cohort have been demonstrated through DNR's thinning and partial cutting timber sales.

Table B.2.2-2. Final EIS SDS Classification - Coded Variables

Stages			Stand-level Variable and Associated Threshold Value									
							Management Activity					
Summarized	Detailed		QMD	Canopy Layer	RD	Stand Age	BioThin Age	Years Since BioThin	Thin Age	Years Since Thin	Snag Ratio1	CWD
Ecosystem Initiation	Ecosystem Initiation		<2									
Competitive Exclusion	Sapling Exclusion		>=2									
	Pole Exclusion		>5									
		or							>0	>=0		
	Large Tree Exclusion		>11									
		or	>11						>0	>=0		
	Understory Development		>=2	>1								
		or	>=2		>=MaxRD							
		or	>=2			>MaxRD Age						
		or	>=2				>0	>=0				
Structually Complex	Botanically Diverse		>=2	>1								
		or	>=2	>1		>=MaxRD Age+60						
		or	>=2	>1			>0	>=0				
		or	>=2	>1	>=MaxRD							
		or	>=2		>=MaxRD	>=MaxRD Age+60						
		or	>=2		>=MaxRD		>0	>=0				
		or	>=2			>=MaxRD Age+60	>0	>=0				
		or	>=2				>0	>5				
		or	>=2	>1		>MaxRD Age						
		or	>=2			>=MaxRD Age+60						
		or	>=2			>MaxRD Age	>0	>5				
	Niche Diveris-ification		>=2	>1		>=MaxRD Age+80					>0.07	>2400
		or	>=2	>1		>=MaxRD Age+80	>0	>0				
		or	>=2	>1			>0	>5				
		or	>=2		>=MaxRD	>=MaxRD Age+80					>0.07	>2400
		or	>=2		>=MaxRD	>=MaxRD Age+80	>0	>0				
		or	>=2		>=MaxRD		>0	>5				
		or	>=2			>=MaxRD Age+80					>0.07	>2400
		or	>=2			>=MaxRD Age+80	>0	>0				
		or	>=2			>MaxRD Age	>0	>5				
		or	>=2			>=MaxRD Age+80	>0	>=0			>0.07	>2400
		or	>=2			>=MaxRD Age+80	>0	>0				
		or	>=2				>0	>5			>0.07	>2400
	Fully Functional		>=2	>1		>=MaxRD Age+160					>0.07	>2400
		or	>=2	>1		>=MaxRD Age+160	>0	>0				
		or	>=2	>1			>0	>40				
		or	>=2		>=MaxRD	>=MaxRD Age+160					>0.07	>2400
		or	>=2		>=MaxRD	>=MaxRD Age+160	>0	>0				
		or	>=2		>=MaxRD		>0	>40				
		or	>=2			>=MaxRD Age+160					>0.07	>2400
		or	>=2			>=MaxRD Age+160	>0	>0				
		or	>=2			>MaxRD Age	>0	>40				
		or	>=2			>=MaxRD Age+160	>0	>=0			>0.07	>2400
		or	>=2			>=MaxRD Age+160	>0	>0				
		or	>=2				>0	>40			>0.07	>2400

Two stages or classes were dropped from the initial classification: "*developing understory*" and "*old natural forests*." The initial grouping of the classifications into ecosystem initiation stage (EIS), *competitive exclusion stage* (CES) and *structurally complex forests* (SCF) was also changed to reflect the logic changes in the classification system.

Understory initiation and developing understory were summarized into one stage as "*understory development*." The available data was insufficient to make a distinction between these stages. The "*old natural forest*" stage in the Draft EIS, was dropped from the classification. The available data was insufficient to distinguish these stands from fully functional, niche diverse stands or even botanically diverse stands.[3]

In summarizing the stages for presentation purposes, the new understory development stage was grouped with the competitive exclusion stages. The Department assumed that while the processes of *competitive exclusion* and *understory development* were different, the structural characteristics of *understory development* were more similar to competitive exclusion than structurally complex stages.

Conclusions

This paper described the forest stand structure classification developed by the Department for the current Sustainable Harvest calculation. A brief introduction described the stand structure management objectives of the Department's Habitat Conservation Plan. Also, the revisions of the Department's classification scheme were discussed and illustrated with examples. More detailed information on the code changes will be provided in the appendices.

Results of the revisions to modeling for the Final EIS demonstrated a "slowing" down of the development of the forest over time. This appeared to be similar to the FVS simulation runs under a no management scenario. The results of the revisions reflected the expectations of expert reviews and model validation.

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[3] A review of the stand development stage model uncovered a number of false positives; i.e. stands with low basal areas and small average stand diameters (QMD) s that were identified as old growth naturals.

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Attachment: DEIS SDS Programming Code

Initial SDS Code

```
Function SDSClass2(Age As Variant, QMD As Variant, RD As Variant, TPA AS _
    Variant, AAge As Variant, AFreq As Variant, Optional K As Variant) As RecSDS
  Dim S As RecSDS, N As Integer
  N = IIf(IsMissing(K), VolC(QMD), QMDC(QMD))
  Select Case N
    Case 1
      S.Code = "1.1"
      S.SDS = "Grass_Forb"
      S.LMP = "EIS"
      S.HCP = "Open"
    Case 2
      S.Code = IIf(RD <= 44.6 And TPA <= 328, "1.2", "1.2.0.1")
      S.SDS = IIf(RD <= 44.6 And TPA <= 328, "ShrubSap", "ShrubSap_closed")
      S.LMP = IIf(RD <= 44.6 And TPA <= 328, "EIS", "SES")
      S.HCP = "Regeneration"
    Case 3
      S.Code = IIf(RD <= 44.6, "1.3.2", "1.3.2.1")
      S.SDS = IIf(RD <= 44.6, "Pole_single", "Pole_single_closed")
      S.LMP = IIf(RD <= 44.6, "URS", "PES")
      If (AAge > 25# And AFreq >= 1) Or (Age >= 40# And AFreq < 0) Then
        S.Code = IIf(RD <= 44.6, "1.3.1", "1.3.1.1")
        S.SDS = IIf(RD <= 44.6, "Pole_multi", "Pole_multi_closed")
        S.LMP = IIf(RD <= 44.6, "URS", "PES")
      End If
      S.HCP = "Pole"
```

Initial SDS Code (Continued)

```
 Case 4
    S.Code = IIf(RD <= 44.6 Or TPA <= 150, "1.4.2", "1.4.2.1")
    S.SDS = IIf(RD <= 44.6 Or TPA <= 150, "Large_single", "Large_single_closed")
    S.LMP = IIf(RD <= 44.6, "URS", "LTS")
    S.HCP = "Closed"
    If (AAge > 45# And AFreq >= 1) Or (Age >= 160# And AFreq < 0) Or _
      (RD <= 44.6 And QMD > 14#) Then
      S.Code = IIf(RD <= 44.6, "1.4.1", "1.4.1.1")
      S.SDS = IIf(RD <= 44.6, "Large_multi", "Large_multi_closed")
      S.LMP = IIf(RD <= 44.6, "DUS", "URS")
      S.HCP = "Complex"
    End If
Case 5
    S.Code = IIf(AFreq < 2 And TPA < 130, "1.5.1", "1.5.1.0.1")
    S.SDS = IIf(AFreq < 2 And TPA < 130, "Giant_multi", "Giant_multi + HE_ND")
    S.LMP = IIf(AFreq < 2 And TPA < 130, "BDS", "NDS")
    S.HCP = IIf(AFreq < 2 And TPA < 130, "Complex", "Fully Functional")
    If AAge > 85# And AFreq >= 2 Then
      S.Code = "1.5.1.0.1"
      S.SDS = "Giant_multi + HE_ND"
      S.LMP = "NDS"
      S.HCP = "Fully Functional"
    ElseIf AAge > 55# And AFreq >= 2 Then
      S.Code = "1.5.1"
      S.SDS = "Giant_multi"
      S.LMP = "BDS"
      S.HCP = "Complex"
    End If
```

Initial SDS Code (Continued)

```
    Case 6
      S.Code = IIf(AFreq < 1 And TPA < 95, "1.6", "1.5.1.0.2")
      S.SDS = IIf(AFreq < 1 And TPA < 95, "OldGrowth_natural", "Giant_multi + HE_FF")
      S.LMP = IIf(AFreq < 1 And TPA < 95, "ONF", "FFS")
      If (AAge > 85# And AFreq >= 2) Or (S.Code = "1.6" And Age < 250#) Then
        S.Code = "1.5.1.0.2"
        S.SDS = "Giant_multi + HE_FF"
        S.LMP = "FFS"
      End If
      S.HCP = "Fully Functional"
    Case Else
      S.Code = "D" & Format(QMD, "0.0") & "/A" & Age & "/AA" & AAge
      S.SDS = "Not defined"
      S.LMP = "Not defined"
      S.HCP = "Not defined"
    End Select
  SDSClass2 = S
End Function
Function QMDC(QMD As Variant) As Integer
  Dim N As Integer
  Select Case Nz(QMD, 0)
    Case Is < 1#
      N = 1
    Case Is < 5#
      N = 2
    Case Is < 10#
      N = 3
    Case Is < 19#
      N = 4
    Case Is <= 23#
      N = 5
    Case Else
      N = 6
  End Select
  QMDC = N
End Function
```

Attachment: FEIS SDS Programming Code

```
Function SDSClass(Age As Integer, YrSOF As Integer, QMD As Double, Layer As Integer, _
    SnagR As Double, CWD As Double, RD As Double, MaxRD As Double, AgeMaxRD As Integer, _
    YrT As Integer, AgeT As Integer, YrBT As Integer, AgeBT As Integer, Optional Spp As _
    String = "WHSF") As RecSDS
  Dim S As RecSDS, N As Long
  If QMD < 2 Then
    S.DNR4 = "EIS"
    S.DNR9 = "EIS"
  Else
    S.DNR4 = "CES"
    S.DNR9 = "SES"
    If QMD > 5 Or (AgeT > 0 And YrSOF >= YrT) Then S.DNR9 = "PES"
    If QMD > 11 Then
      S.DNR9 = "LTS"
      If S.DNR9 = "PES" And (AgeT > 0 And YrSOF >= YrT) Then S.DNR9 = "LTS"
    End If
    If Layer > 1 Or RD >= MaxRD Or Age > AgeMaxRD Or (AgeBT > 0 And YrSOF >= YrBT) Then
      S.DNR4 = "BDS"
      S.DNR9 = "UDS"
      If Layer > 1 Or Age - AgeMaxRD >= 60 Or (AgeBT > 0 And YrSOF - YrBT > 5) Then S.DNR9 =
"BDS"
      If (SnagR > 0.07 And CWD > 2400) Or (AgeBT > 0 And YrSOF > YrBT) Then
        If Age - AgeMaxRD >= 80 Then
          S.DNR4 = "SCF"
          S.DNR9 = "NDS"
          If Age - AgeMaxRD > 160 Then S.DNR9 = "FFS"
        End If
        If AgeBT > 0 Then
          If YrSOF - YrBT > 5 Then S.DNR9 = "NDS"
          If YrSOF - YrBT > 40 Then S.DNR9 = "FFS"
        End If
      End If
    End If
  End If
  SDSClass = S
```

```
End Function

Function Snag(TPA As Double, AFreq As Integer, ID As Integer) As Double
   Dim Standing As Double
   Standing = IIf(AFreq = -1, 0.7, 0.22)
   Snag = TPA * IIf(ID = 0, Standing, 1 - Standing)
End Function

Function CDWD(Yr As Integer, YRORG As Integer, CV As Double, DBH As Double) As Double
   Dim kf As Double
   If CV = 0 Then
     CDWD = 0
   Else
     kf = IIf(DBH >= 15, 0.008, 0.01)
     CDWD = CV * IIf(DBH >= 6, Exp(-kf * (Yr - YRORG)), 1)
   End If
End Function
```

B.2.3 Photographic Examples of Stand Development Stages and Silvicultural Harvest Treatments - This page is intentionally left blank.

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Photographic examples of stand development stages and silvicultural harvest treatments

Washington Department of Natural Resources (DNR) developed a forest classification system to illustrate ecological development of forest stand structures. DNR is working to help create more acres of structurally complex forest from the less complex "competitive exclusion" phases throughout the western Washington forest landscape. DNR manages forested trust lands to earn revenue and provide habitat for many native wildlife species.

The stand development stages used in this analysis are adapted from three principal sources: Brown (1985), Carey et al. (1996), and Johnson and O'Neil (2001) (Chapter 4.2). DNR's classification system summarizes forest stand structures using three major categories with eight more detailed stand development stages. This provides a systematic comparison of forest management Alternatives. The following chart, descriptions, and photos illustrate the stand development stages.

Summarized Stand Development Stages Under Current Conditions

Less Complex Forest ↑

Summarized Stand Development Stage	Stand Development Stage	Acres	Percent of Westside Forested Trust lands
Ecosystem Initiation	Ecosystem Initiation	105,240	8
Competitive Exclusion	Sapling Exclusion	234,979	17
	Pole Exclusion	286,880	21
	Large Tree Exclusion	226,347	16
	Understory Development	196,417	14
Structurally Complex	Botanically Diverse	324,725	23
	Niche Diversification	3,681	0
	Fully Functional	12,435	1
Total		**1,390,704**	**100**

Data source: Model output data - stand development stages

More Complex Forest ↓

Regeneration harvesting follows the Habitat Conservation Plan guidelines and state Forest Practice Rules. Legacy and leave trees remain clumped and scattered. Some trees continue standing, while others are left on the ground. Riparian (streamside) and other habitat protections are part of this activity. In addition, adjacent stands are not harvested in similar ways until the newly regenerated trees on this stand are well established.

DESCRIPTION OF CLASSES (ADOPTED FROM CAREY ET AL. 1996)

Natural disturbances, tree growth, and harvest can change forest structures.

ECOSYSTEM INITIATION STAGE

Death or removal of mature forest overstory trees by wildfire, windstorm, insects, disease, or timber harvest leads to establishment of a young forest ecosystem. The absence of overstory trees leads to the re-establishment of a young forest ecosystem. This open canopy forest is dominated by herbs, forbs, and small trees.

COMPETITIVE EXCLUSION STAGE

Trees fully occupy the site and compete for light, water, nutrients and space. Most other vegetation and many trees become suppressed and trees die. This class has four subcategories. The first three—**Sapling Exclusion, Pole Exclusion and Large Tree Exclusion**—are determined by the tree size, and the last—**Understory Development**—is determined by reduced tree competition**.**

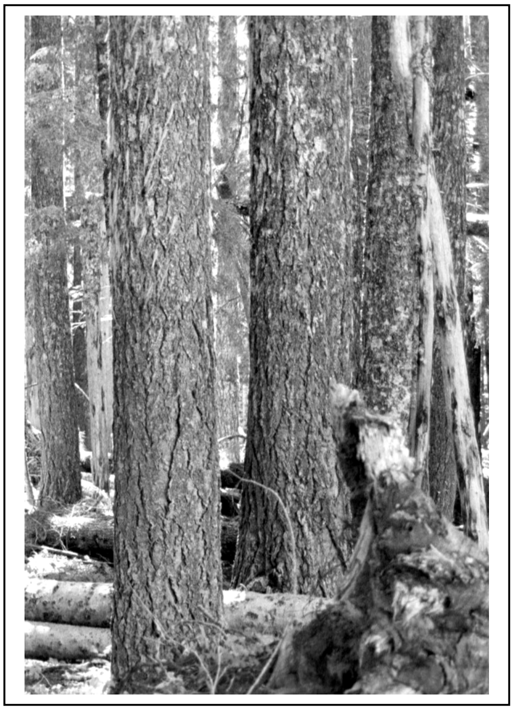
Sapling Exclusion

The pioneer of competitive exclusion is the sapling exclusion stage. It has a dense canopy from the ground up. Shrubs and branches of regenerated trees begin to intertwine.

Pole Exclusion

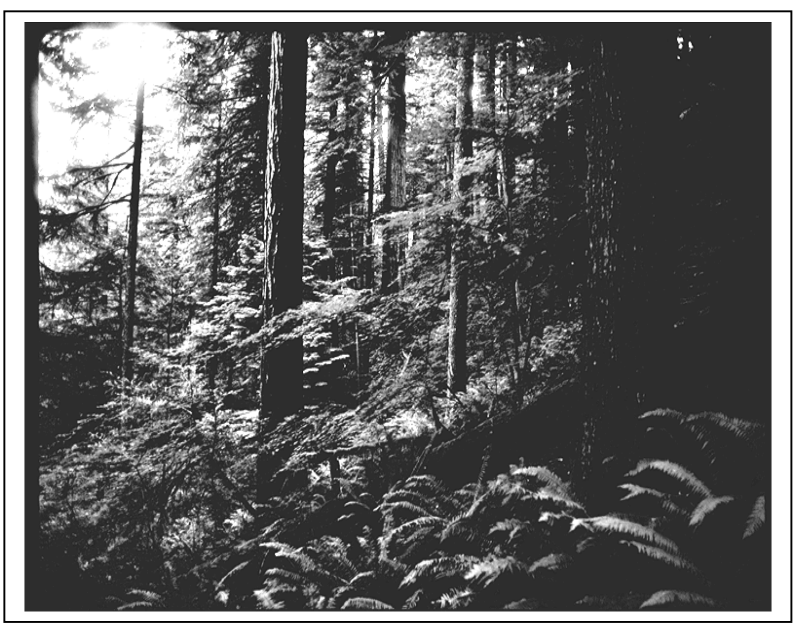
Closed canopies feature taller, intermediate-sized trees. Understory forest floor plants are absent. Mortality of suppressed trees is evident.

Large Tree Exclusion



Even larger, closely spaced trees of similar heights compete, perpetuating mortality and suppression of forest floor plants. There are not enough large openings to allow light for forest floor plants to grow. Mortality of larger trees is evident.

Understory Development

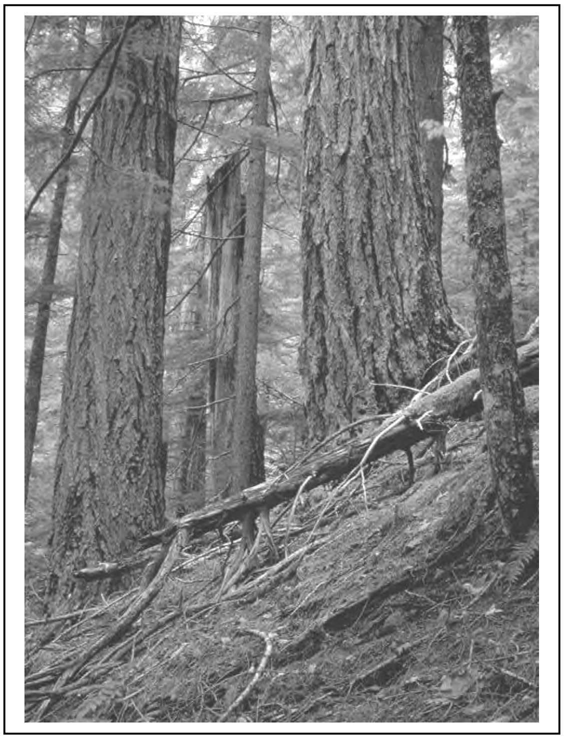


As overstory trees die, fall down, or are harvested, the competetive exclusion of overstory trees fades and canopy gaps become larger. Light penetrates the canopy gaps and an understory of trees, forbs, ferns, and shrubs develops. There is little diversification of plant communities.

STRUCTURALLY COMPLEX

Structurally complex stands are described by three stages: the Botanically Diverse, Niche Diversification, and Fully Functional.

Botanically Diverse



Multiple canopies of trees and communities of forest floor plants are evident. Large and small trees have a variety of diameters and heights. Decayed and fallen trees are lacking abundance.

Niche Diversification

Coarse woody debris, cavity trees, tree litter, soil organic matter, and diversity of forest floor plant communities are evident, as well as the wildlife that use this type of habitat. Multiple canopies of trees are present. Large and small trees have a variety of diameters and heights.

Fully Functional

The most complex of the forest structures, the Fully Functional forest has large-scale habitat elements such as rotting fallen trees or "nurse logs," onto which trees and other vegetation grow. The added complexity enables the increased interactions that provide for the life requirements of diverse vertebrates, invertebrates, fungi, and plants.

Other examples of forested trust lands timber harvests

Thinning generates revenues for trusts by harvesting some trees. Thinning reduces overstory tree competition. If enough overstory trees are harvested, light reaches the forest floor through canopy openings, encouraging the understory growth of trees, bushes, forbs, lichen, and other plants that provide habitat and soil stability.

One example of a DNR thinning

Forest before thinning.

Forest after thinning. Note that more sky is visible through the tree tops than in the photograph above.

Another example of a DNR thinning

Forest in competitive exclusion before thinning. Insufficient light through treetops and no forest floor plants.

Two years after thinning, showing substantial growth of vegetation on the forest floor.

An understory of trees may not develop as the overstory canopy closes.

Examples of other silvicultural options

Photo by J. Alan Wagar   Two-age unit immediately after harvest – aeriel oblique

Photo by J. Alan Wagar - Patch cut unit immediately after harvest –aerial oblique
(From Curtis, Robert O.; Marshall, David D.; DeBell, Dean S., eds. 2004 Silvicultural options for young-growth Douglas-fir forests: the Capitol Forest study—establishment and first results. Gen. Tech. Rep. PNW-GTR-598. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 110 p.)

REFERENCES

Brown F. W., (editor) 1985 Management of wildlife and fish habitats in forest of western Oregon and Washington. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region Portland. OR. 2 volumes.

Carey, A., C. Elliot, B.R. Lippke, J. Sessions, C. J. Chambers, C.D. Oliver, J.F. Franklin and M. G Raphael 1996 Washington Forest Landscape Management Project – A pragmatic, ecological approach to small-landscape management. USDA Forest Service, Washington State Department of Fish and Wildlife and Washington State Department of Natural Resources

Johnson, D.H. and T. A. O'Neil (managing directors) 2001. Wildlife-habitat relationships in Oregon and Washington. Oregon State University Press p.685, plus Appendices and CD-ROM

B.2.4 Differences Between Alternative 6 and the Preferred Alternative

This section contains Table B.2.4-1, Summary of Policy, Procedural, and Modeling Differences Between Alternative 6 and the Preferred Alternative.

Table B.2.4-1. Summary of Policy, Procedural, and Modeling Differences Between Alternative 6 and the Preferred Alternative

Management Issue	Policy, Procedure, Task Reference	Alternative 6	Preferred Alternative	Modeling Differences
Ownership groups	Policy No. 6	Change policy (20 groups)	Change policy (20 groups)	Same
Even-flow of harvest	Policy No. 4 PR 14-001-010 TK 14-001-020	+/- 25% flow	+/- 25% flow	Same
		Change procedure, task	Change procedure, task	Same
Harvest regulation	Policy No. 5	Value	Value	Same
Maturity criteria and silviculture	Policies No. 4, 11, 30, 31 PR 14-005-020	Change policy By Value Regimes designed to max NPV subject to objectives Update policy discussion (Nos. 4, 11)	Change policy By Value Regimes designed to max NPV subject to objectives Update policy discussion (Nos. 4, 11)	Very light thinning excluded from Preferred Alternative modeling, thought to be un-economical
		Change procedure	Change procedure	Same
Northern spotted owl conservation	Nesting, roosting, foraging, and dispersal PR 14-004-120	As HCP envisioned Change procedure	As HCP envisioned Change procedure	Both alternatives' model design was to demonstrate biodiversity pathways. Alternative 6 resulted in modeling without regeneration harvest for approximately the first 70 year of the model. The Preferred Alternative used a combination of heavy and light thinnings and regeneration harvest to demonstrate biodiversity pathways.
Old forest components	Owl circles PR 14-004-120 Policy No. 14 (Old Growth Research Areas)	Deferred until 2007 Change procedure	Deferred until 2007 except in the OESF where Admin. circles release 2004 Change procedure	Same approach, except OESF Admin. circles not deferred in model
		10-15% of HCP unit targeted Change/new policy	10-15% of HCP unit targeted Change/new policy	Same
	Task 14-001-010 (Maintaining Mature Forest Components)	New procedure/task	New procedure/task	Same
	Task 14-001-010 (Maintaining Mature Forest Components)	50/25 replaced with SEPA checklist Change Task	50/25 replaced with SEPA checklist Change Task	Same
	PR 14-006-090 (Legacy and Leave Tree Levels)	7% to min. 8 trees Change procedure	7% to min. 8 trees Change procedure	Same
Riparian and wetland areas	PR1 14-004-150	Biodiversity thinnings for restoration under HCP Change procedure (Requires Services' agreement)	Biodiversity thinnings for restoration under HCP Change procedure (Requires Services' agreement). Board wished to see less area of activities in riparian areas	Riparian modeling strategy in Preferred Alternative updated from an extensive strategy to an intensive strategy (see note below)
Marbled murrelets	No procedure or policy change	No procedure or policy change	No procedure or policy change	Occupied sites and occupied reclassified habitat model as deferred from harvest in Preferred Alternative. In Alternative 6, these areas were released in 2007.

HCP = Habitat Conservation Plan
OESF = Olympic Experimental State Forest
SEPA = State Environmental Policy Act

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B.2.5 Definition of Harvest Types

Washington Department of Natural Resources (DNR) carries out many types of silvicultural activities that result in the harvest of trees on western Washington forested state trust lands. Some of these—such as pre-commercial thinnings and cutting of competing vegetation—do not result in merchantable timber, and are not included in this discussion on harvest types.

The two basic reporting categories used for silvicultural activities resulting in merchantable timber are thinnings and clear-cuts. DNR typically designs thinnings for dense, closed stands with both small- and large-diameter trees.

Thinning does not typically result in significant regeneration – that is, growth of new groups or a 'cohort' of trees within the stand. Clear cuts result in significant regeneration. In the forest structure-oriented silviculture of today, regeneration harvests can include shelterwoods, partial harvests, variable density thinning, patch cuts, and other harvest design options.

To simplify the reporting of the harvest types that make up the sustainable harvest, three reporting categories are presented:

- Low-volume removal harvest (Harvest Type "A") – less than 11 thousand board feet per acre (11 mbf/acre) removed
- Medium-volume removal harvest (Harvest Type "B") – between 11 and 20 mbf/acre removed
- High-volume removal harvest (Harvest Type "C") – greater than 20 mbf/acre removed

Harvest type "A" is usually the removal of small-diameter trees from the stand. These harvests are typically thinnings in small-diameter closed stands, but may include other harvest treatment depending on the mixture of tree species, site potential, and location of a stand.

Harvest type "B" is typically a thinning in large-tree diameter stands. However, the category may include other harvest methods, for example variable density thinnings, patch-cutting, and clear cuts in hardwood stands. Stand regeneration may be associated with some of these harvest types.

Harvest type "C" represents the harvest design of a larger number of trees and high volume removed from the stand. Harvest methods within this category are typically associated with stand regeneration. Most common harvest methods are clear cuts, partial harvest, shelterwoods, and variable density thinnings. The precise harvest method depends on the mixture of tree species, site potential and location of the stand, and, of course, the management goals for the site.

B.2.5.1 DNR Definitions for Specific Timber Harvest Types

Smallwood Thinning (typically harvest Type A): A partial-cut timber harvest in young stands, typically occurring before maturity criteria have been met (see discussion of maturity criteria in Chapter 2 page 2-11). Smallwood thinning maintains or enhances the growth potential and quality of the trees left in the stand.

Shelterwood Removal Cut (typically harvest Type A): The second or final harvest in a series conducted as part of the even-aged shelterwood system. The purpose is to remove overstory trees that create shade levels that are too high for the new understory trees to thrive.

Seed Tree Removal Cut (typically harvest Type A): The second or final harvest in a series conducted as part of the even-aged seed tree silvicultural system. The purpose is to remove overstory trees that create shade levels that are too high for the new understory trees to thrive.

Selective Product Logging (typically harvest Type A): A timber harvest that removes only certain high-value species above a certain size. This is typically a pole/cabin log sale or an individual high-value tree removal.

Temporary Retention Removal Cut (typically harvest Type A): The second or third harvest in a series conducted as part of the even-aged temporary retention silvicutural method. Some overstory trees are removed to reduce shade levels that are too high for the new understory to thrive. Several removal harvests may be necessary to establish a second stand under an overstory of scattered retention trees.

Late Rotation Thinning (Older Stand Thinning) (typically harvest Type B): A partial-cut timber harvest that extends the stand beyond its maturity criteria to achieve a silvicultural objective (e.g., habitat, visual, protection of sensitivity resource) that requires a stand of large trees. Stands eligible for late rotation thinning are typically at or beyond their maturity criteria.

Phased Patch Regeneration Cut (typically harvest Type B): An even-aged timber harvest method using small patch cuts (1 to 5 acres in size) to progressively harvest and regenerate a single stand over a period (typically 10 to 15 years). Several separate patches are harvested at a single point in time within a forest management unit. After an adequate green-up period (5 to 10 years) of new trees in the cut areas, additional patches are harvested and the process is repeated until the forest unit is entirely harvested.

Variable Density Thinning (typically harvest Type B or C): Thinning to create a mosaic of different stand densities on a scale of approximately 1/4 to 1 acre. The thinning prescription objective is to accelerate structural diversity development in areas where owl habitat is needed or to meet other objectives. Snag, down wood, and underplanting treatments are also typically included in these thinnings.

Salvage (typically harvest Type C): Logging of trees that are dead, dying, or deteriorating due to fire, insect damage, wind, and disease injuries.

Clear Cut (typically harvest Type C): A timber harvest that removes the entire stand of trees except for reserve trees designated for habitat. Reserve trees may be clumped at densities exceeding 8 trees per acre. Reserve trees may be clumped or dispersed throughout portions of the stand at densities less than 10 trees per acre.

Shelterwood Intermediate Cut (typically harvest Type C): The first timber harvest in a series conducted as part of the even-aged shelterwood system. The purpose is to provide shelter (typically shade) and possibly a seed source for the seedlings that are regenerating at the site. Up to 20 trees per acre may be left following this harvest.

Seed Tree Intermediate Cut (typically harvest Type C): The first timber harvest in a series conducted as part of the even-aged seed tree silvicultural system. The purpose is to provide a desirable seed source to establish seedlings. Up to 10 trees per acre may be left following this harvest.

Temporary Retention First Cut (typically harvest Type C): A partial-cut timber harvest in which selected overstory trees are left for a portion of the next rotation. Shelterwood and seed tree harvests are traditional examples with relatively short retention periods (for those trees left after harvest). Habitat objectives increase the length of retention periods up to the time of precommercial or smallwood thinnings. The purpose of this harvest method is to retain overstory trees without slowing the establishment of a new stand. Two-age stands can be an outcome when some level of overstory is left through the entire rotation.

Two Age Management – Westside (typically harvest Type C): An even-aged harvest method that is essentially the same as a temporary retention except that the overstory trees are not planned for removal until the time of the planned rotation for the younger component of the stand. Both will be cut at the same time.

B.2.6 Harvest Deferrals

Table B.2.6-1. Summary of Major Long-Term and Short-Term Deferrals

	Alternatives					
Description	**1**	**2**	**3**	**4**	**5**	**PA**
0.25-mile buffer around location of eagle nests	Indef	-	-	-	-	-
Older forests equal to or greater than 150 years	-	-	-	Indef	-	-
Marbled murrelet occupied sites	Indef	2007	2007	2007	2007	9999
Marbled murrelet reclassified habitat (occupied)	Indef	2007	2007	2007	2007	9999
Marbled murrelet reclassified habitat (non-occupied)	Indef	2007	2007	2007	2007	2007
Additional murrelet reclassified habitat for North Puget and South Puget	Indef	2007	2007	2007	2007	9999
Buffer around Nesting, Roosting, and Foraging Management nest core areas	Indef	2052	2052	2052	2052	2052
300-acre nest patch core areas	Indef	2052	2052	2052	2052	2052
Admin Stat. 1R spotted owl circles (within OESF)	Indef	-	-	-	-	-
Admin Stat. 1R spotted owl circles (outside OESF)	Indef	-	2007	2007	2007	2007
Admin SW spotted owl circles	Indef	-	2006	2006	2006	2006
Memo 1 spotted owl circles	2007	2007	2007	2007	2007	2007
0.25-mile buffer around location of peregrines	Indef	-	-	-	-	-

Note:
When deferred areas are released, the land within the deferred area is classified according to one of three land classes: riparian and wetlands, uplands with specific management objectives or uplands with general management objectives.
Indef = Harvest is suspended for the indefinite future. DNR may reconsider this deferral at some time in the future.
OESF = Olympic Experimental State Forest

Table B.2.6-2. Acres of Land Deferred from Timber Harvest and Acres by Land Classification for Each Alternative

Year	Alts.	Acres Deferred from Timber Harvest: Long-term Deferrals	Acres Deferred from Timber Harvest: Short-term Deferrals	Land Classification: Riparian and Wetlands	Land Classification: Uplands with Specific Objectives	Land Classification: Uplands with General Objectives
2004	1	486,000	40,000	237,000[1/]	323,000	305,000
	2	281,000	208,000	215,000	343,000	343,000
	3	213,000	301,000	239,000	328,000	310,000
	4	238,000	280,000	238,000[1/]	326,000	309,000
	5	213,000	300,000	239,000	329,000	309,000
	PA	213,000	302,000	238,000	328,000	310,000
2013	1	486,000		251,000[1/]	348,000	306,000
	2	281,000		278,000	477,000	354,000
	3	213,000		346,000[1/]	477,000	354,000
	4	238,000		336,000	464,000	354,000
	5	213,000		346,000	477,000	354,000
	PA	232,000		329,000	475,000	354,000

Data Source: Model output data (State of the Forest)

[1] The majority of the area in riparian and wetlands in these Alternatives is effectively in long-term deferral.

B.2.7 Silvicultural Implementation Strategies

Table B.2.7-1. Summary of the Range of Implementation Strategies Modeled in the Alternatives

Silvicultural Elements		Alternatives: 1	2	3	4	5	PA
Thinning – stand level	Removed volume limit[1/]	Up to 35%	Up to 35%	Up to 35%	Up to 35%	Up to 35%	Up to 70% for biodiversity pathways
	Pre-thin stand RD	55	None	55	55	55	55
	d/D[2/]	0.9	0.9	0.9	0.9	0.9	0.8
Thinning harvest – forest level	Priority	Second	Second	Second	First	Third	Second
	Target[3/]	17%	20%	17%	32%	22%	25%
fertilization		Not applied	Not applied	Not applied	Not applied	Applied [4/]	Applied
Reforestation methods		Planted using improved stock	Planted using improved stock	Planted using improved stock	Natural Regeneration	Planted using improved stock	Planted using improved stock
Assessment of sensitive resources [5/]		30%	50%	50%	30%	50%	50%

[1/] The percent is of the pre-thin stand volume.

[2/] The d/D ratio is the average diameter of trees removed (d) vs. trees of the original stand (D). A uniform thinning from below is typically between 0.8 and 1.0; overstory removal is 1.0 and greater.

[3/] The thinning target is expressed as the average percentage of the total harvest target used in modeling the Alternative.

[4/] Applied to Douglas-fir stands on better sites (site class I, II and III).

[5/] The percent represents the area of "uplands with specific management objectives" available for regeneration-type harvests.

B.2.8 Modeling Process: Participants and Acknowledgements

Steering Committee

- The Lands Steward, Bruce Mackey
- The Upland Region Operations Coordinator, Jack Hulsey
- The Policy Director, Rick Cooper, and then Craig Partridge
- Land Management Division Manager, Julie Sandberg, John Baarspul, and then Gretchen Nicholas
- Region Participation, various participants.

Technical Review Committee

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- Dr. Andrew Carey (USDA Forest Service),
- William Hamilton (American Forest Resources),
- Dr. Jim Hotvedt (DNR),
- Dr. Valerie LeMay (UBC),
- Bruce Lippke (UW),
- Roger Lord (Boise Cascade.),
- Dr. Fred Martin (DNR),
- Mike Mossmen (Port Blakely Tree Farms, L.P.),
- Steven McConnell (Northwest Indian Fisheries Commission)
- Pam Overhulser (Oregon Department of Forestry)
- Dr. Don Reimer (DRS Inc.).
- Dr. John Sessions(OSU)

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- Heather Cole
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- Joanne Snarski (to June 2000)
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- Wendy Gerstel
- Dave Gordon
- Louis Halloin
- Pete Holmberg
- Scott Horton
- Sabra Hull
- Deb Lindley
- Fred Martin
- Teodora Minkova
- Karen Ripley
- Tami Riepe
- Jim Ryan
- Steve Saunders
- Blanche Sobottke
- Pene Speaks
- Lee Stilson

With assistance from D.R. Systems

- Don Reimer
- Michael Bowering
- Trina Sunderland
- Kristine Allen
- Mark Perdue

B.3 MODELED HARVEST LEVELS

Tables B.3-1 and B.3-2 provide westside sustainable forestry harvest levels by Alternative.

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Table B.3-1. Westside Sustainable Forestry Harvest Levels in Million Board Feet per Year, by Ownership Group, for Period 2004-2067

Trust Group	Ownership Group	Alternative 1							Alternative 2							Alternative 3							Alternative 4							Alternative 5							Preferred Alternative						
		1[1/]	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Federal Granted Trusts	DNR Central Region	42	41	42	42	43	44	38	66	65	70	71	68	76	75								62	69	68	56	64	72	54														
	DNR Northwest Region	44	41	23	34	32	38	47	56	57	41	60	59	59	53								48	49	49	38	50	51	51														
	DNR Olympic Region	7	8	7	8	7	7	8	17	15	16	13	14	14	13								14	14	13	14	12	14	14														
	DNR South Puget Sound Region	41	40	41	30	27	24	25	34	34	36	35	34	36	36								24	25	25	25	26	26	26														
	DNR Southwest Region	56	55	55	44	43	44	45	65	61	54	66	64	55	56								56	58	58	51	58	56	61														
	Federal Grants as one group																													260	334	295	254	243	254	265	307	245	214	211	261	244	265
	Capitol State Forest	39	38	39	39	35	39	37	42	46	47	51	43	43	33								39	38	39	32	38	41	36	41	52	44	46	47	46	49	37	48	31	45	30	33	30
	OESF[2/]	18	20	28	29	29	29	30	63	55	93	89	91	89	97								10	8	7	9	12	13	12	136	109	113	112	103	91	47	77	58	105	94	95	91	80
Forest Board Transfer	Clallam County	7	7	7	6	7	7	6	15	27	16	17	17	19	16								17	17	17	17	17	17	17	23	24	23	19	23	23	21	20	19	16	17	14	16	15
	Clark County	12	12	12	12	11	11	7	13	16	10	13	12	13	6								10	10	10	10	10	10	10	13	12	13	12	11	12	15	10	14	7	13	8	9	6
	Cowlitz County	5	5	5	5	5	5	4	6	6	5	5	5	4	4								5	5	5	5	5	5	5	6	6	5	5	6	6	4	5	6	3	4	4	4	2
	Grays Harbor Co.	0	0	0	0	0	0	0	0	0	0	0	0	0	0								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jefferson County	5	5	4	4	3	3	4	6	6	7	5	5	5	5								3	3	4	3	4	4	4	7	6	6	6	7	7	6	6	7	5	5	5	4	4
	King County	9	10	10	8	9	5	4	8	8	8	8	8	8	8								6	6	6	6	6	6	6	11	12	10	8	10	9	10	10	5	3	7	10	8	10
	Kitsap County	3	2	2	2	2	1	2	3	4	2	3	3	3	3								2	2	2	2	2	3	2	3	3	2	3	4	3	3	2	2	2	2	2	2	2
	Lewis County	15	15	14	14	14	14	14	21	21	19	20	19	17	20								18	19	17	18	18	19	19	22	18	20	19	21	19	21	18	17	18	15	16	13	12
	Mason County	8	8	7	6	4	3	3	9	9	8	10	9	10	8								7	7	6	7	7	7	5	9	8	7	9	10	10	10	5	8	5	4	4	9	3
	Pacific County	4	4	5	5	5	5	5	8	8	8	9	8	8	8								7	7	7	7	7	7	7	9	13	9	7	7	10	6	10	8	8	7	7	7	9
	Pierce County	4	4	4	4	4	4	4	4	4	4	5	4	6	4								1	1	1	1	1	1	1	5	6	5	5	3	5	4	7	3	4	4	4	3	2
	Skagit County	30	28	20	27	29	30	32	35	37	31	39	38	41	38								32	32	18	34	33	35	35	36	50	32	38	38	36	37	49	18	33	34	36	36	32
	Skamania Co.	5	7	7	7	7	7	7	14	11	15	10	13	15	7								3	4	5	4	5	5	5	15	14	15	14	12	18	17	21	13	10	9	19	12	12
	Snohomish Co.	23	23	23	24	21	23	24	28	30	30	30	29	31	29								27	27	28	27	27	27	21	27	40	31	32	29	28	32	27	23	22	22	23	24	24
	Thurston County	3	3	3	3	3	3	3	6	2	6	2	5	1	2								3	3	3	3	3	3	3	4	4	4	4	4	4	5	5	3	4	3	3	4	3
	Wahkiakum Co.	4	4	4	4	4	4	3	5	5	5	5	5	6	6								6	6	6	6	6	6	6	7	9	8	8	6	7	8	6	5	5	5	5	4	5
	Whatcom County	11	11	11	10	10	10	11	14	16	15	16	16	14	15								13	13	13	13	13	13	13	13	18	19	13	16	14	15	14	11	11	11	13	13	13
All trusts as one Westside group																663	737	479	655	883	626	738																					
Westside harvest level		396	391	374	364	352	360	364	537	541	546	582	568	572	541	663	737	479	655	883	626	738	411	422	406	389	424	437	414	648	738	663	613	598	601	575	636	514	506	511	559	537	528

1/ Numbers represent average annual harvest for each decade period (1= 2004 to 2013, 2 = 2014 to 2023, etc.) except 7, which represents four years (2064 to 2067)
2/ OESF = Olympic Experimental State Forest

Table B.3-2 Westside Sustainable Forestry Harvest Levels in Million Board Feet per Year by State Trust, by Alternative, for Period 2004-2067

	Alternative 1							Alternative 2						
TRUSTS	1[5]	2	3	4	5	6	7	1	2	3	4	5	6	7
Agricultural School	9	10	6	7	5	8	6	9	13	13	12	10	12	11
Capitol Grant	34	27	22	20	19	19	20	40	32	37	35	29	28	32
Charitable/Educational/Penal & Reformatory Instit.	14	10	9	10	7	8	6	15	14	10	9	10	11	11
Common School and Indemnity	113	118	118	114	118	113	124	174	162	183	203	203	208	200
Community College Forest Reserve	1	3	1	3	2	1	3	1	3	1	3	2	1	3
Escheat	2	1	1	0	1	1	1	2	1	1	1	2	1	2
Normal School	6	5	8	7	6	8	6	12	9	8	15	11	15	9
Scientific School	23	24	18	18	12	14	11	22	27	22	25	27	19	19
State Forest Board Purchase	33	28	29	27	21	29	33	37	45	37	46	32	35	31
State Forest Board Transfer	159	155	146	149	146	146	140	212	220	214	216	213	219	209
University - Original	1	0	1	1	0	1	1	0	3	1	2	1	1	2
University - Transferred	1	10	16	7	15	13	12	12	12	20	16	28	21	12
Grand Total	396	391	374	364	352	360	364	537	541	546	582	568	572	541

	Alternative 3							Alternative 4						
TRUSTS	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Agricultural School	8	20	16	12	23	15	13	12	11	9	6	10	11	12
Capitol Grant	47	45	32	38	69	49	50	29	28	25	22	25	23	16
Charitable/Educational/Penal & Reformatory Instit.	17	19	8	12	17	11	12	12	12	12	11	9	11	10
Common School and Indemnity	180	202	184	241	322	207	339	119	129	128	114	133	148	150
Community College Forest Reserve	0	4	1	3	2	1	2	1	1	1	1	4	2	2
Escheat	2	1	1	2	2	1	4	1	1	2	1	1	1	3
Normal School	11	11	12	16	14	16	13	7	5	7	6	8	10	7
Scientific School	28	49	22	23	31	23	24	23	25	23	24	23	17	16
State Forest Board Purchase	60	52	21	46	43	41	42	36	33	31	27	31	31	27
State Forest Board Transfer	299	308	159	244	328	242	231	167	168	154	172	174	175	166
University - Original	1	2	1	1	2	1	1	1	1	1	0	1	1	1
University - Transferred	9	24	21	17	32	20	7	3	8	15	5	4	7	4
Grand Total	663	737	479	655	883	626	738	411	422	406	389	424	437	414

	Alternative 5							Preferred Alternative						
TRUSTS	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Agricultural School	11	19	18	15	14	9	11	17	15	13	13	10	14	10
Capitol Grant	58	50	42	39	34	40	38	58	36	34	31	31	42	39
Charitable/Educational/Penal & Reformatory Instit.	16	18	14	12	11	15	16	19	13	11	11	11	15	12
Common School and Indemnity	202	242	252	216	209	195	177	197	173	180	184	225	183	185
Community College Forest Reserve	0	5	3	3	1	1	4	1	3	2	3	1	1	3
Escheat	1	3	2	2	2	1	2	1	1	1	2	2	1	1
Normal School	13	12	15	16	16	15	7	9	8	13	10	15	12	17
Scientific School	27	43	27	20	28	28	29	32	30	22	20	30	26	37
State Forest Board Purchase	45	50	33	40	38	42	50	42	45	27	34	31	34	28
State Forest Board Transfer	260	268	235	224	228	242	234	248	178	179	186	193	192	186
University - Original	1	2	1	1	1	2	1	1	1	1	1	1	1	0
University - Transferred	13	28	21	25	16	12	6	12	11	22	17	8	16	10
Grand Total	648	738	663	613	598	601	575	636	514	506	511	559	537	528

[5] Numbers represent a decade periods (1= 2004 to 2013, 2 = 2014 to 2023, etc..) except 7 which represents four years (2064 to 2067)

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